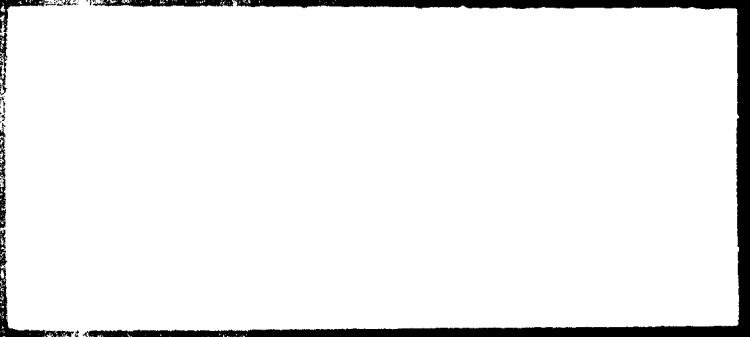

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13. ABSTRACT

Hundreds of thousands of items of military equipment and repair parts, valued in excess of $13 billion are stocked by the military services and the Defense Supply Agency as war reserves. The items selected as war reserves are determined by each military service subject to selection criteria provided by a Department of Defense directive. This study examines the selection criteria and methods for computing war reserve requirements. The study identifies a number of problem areas resulting from the application of current criterion and computational methods. The most significant problem area in determining the appropriate range and depth of war reserve requirements is the lack of meaningful measurements of item essentiality, contingency or mission essentiality, and component force essentiality. Additional problem areas are identified including: 1) scope of selection policy and criteria; 2) period of time for which war reserves are required to support a contingent combat operation; 3) item interchangeable and substitutable consideration; 4) funding constraints; and 5) cost/effectiveness trade-off consideration.

The study results in two principal recommendations. The first provides a short-range solution to the problems described in the report, and recommends fourteen supplementary policies to be incorporated into the current Department of Defense Directive which prescribes war reserve selection criteria. The second principal recommendation offers a more long-range solution, and proposes methods and techniques for the development of quantitative measurements of item, contingency, and component force essentiality. The second principal recommendation will provide a basis for appropriately allocating funds among and within the military services for war reserve materiel.

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IDENTIFICATION OF WAR RESERVE STOCK

TASK 72-4

June 1972

Prepared pursuant to Department of Defense Contract No. SD-271.

LOGISTICS MANAGEMENT INSTITUTE
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Washington, D. C. 20016

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SUMMARY

Hundreds of thousands of items of military equipment and repair parts with an estimated value in excess of $13 billion are stocked by the military services and the Defense Supply Agency as war reserves. War reserves are intended to provide a source of equipment and parts necessary to sustain a combat engagement until resupply can be accomplished. The potential engagements for which war reserves are provided include scores of specific minor contingencies or operational projects and three major contingencies described and approved by military department headquarters, the Joint Chiefs of Staff or the Office of the Secretary of Defense.

The items selected as war reserves are determined by each military service subject to selection criteria provided by DoD Directive 3005.5.[1] The current selection criteria do not effectively screen out war reserve items which are relatively insignificant, provide a consistency among the types of items which are selected, or provide a cost/effective basis for allocating available funds for war reserves.

The purpose of this task is "to develop more definitive criteria to apply in identifying war reserve stock and to develop recommended DoD policies which prescribe requirements for using such criteria. The criteria developed should be

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[1] DoD Directive 3005.5, "Criteria for Selection of Mobilization Reserve Items," November 8. 1965.

sufficiently definitive to: a) provide a basis for identifying war reserve items and stock uniformly among the military departments; and b) allow for an effective and balanced allocation of war reserve funds among the military departments and various commodities within the military departments."

In accomplishing this task, LMI first examined the current policies, methods, and selection criteria applied by the military service in determining which items to stock as war reserves. Next, a number of major problem areas resulting from the application of current policies, methods and selection criteria were identified and analyzed. Finally, a number of alternative methods and criteria were examined and several recommendations developed to provide both short and long range improvements to the process of determining war reserve requirements.

The most significant problem area in determining the appropriate range and depth of war reserve requirements is the lack of meaningful measurements of item essentiality. Current selection criteria provided in DoD Directive 3005.5 specify that items selected as war reserves be essential for the operational effectiveness of combat and combat support forces, essential weapons and equipment, and the logistics support system. The military services apply the current selection criteria in determining which items to stock as war reserves, but no distinction is made among the items selected with regard to the relative essentiality of the items. The items selected as war reserves range from highly significant combat and survival equipment, such as weapons, weapon components, gas masks and survival kits, to less significant equipment such as sunglasses, insect repellants, binoculars

and wrist watches. No measurements of item essentiality are available and thus no basis currently exists for effectively allocating funds for war reserves among the items considered essential.

Item essentiality cannot be effectively considered by a direct comparison of one item to another. Item essentiality is dependent upon the essentiality of the component force which requires the item and upon the essentiality of the mission the component force is expected to perform. The essentiality of various component forces and the essentiality of various missions or contingencies can only be determined by the judgments of experienced military personnel. If such judgments can be quantified in a meaningful way, a sound basis will exist by which the logistician can provide to the military forces a cost/effective balance of war reserve materiel.

This report develops several methods for establishing measurements of item essentiality, contingency or mission essentiality, and component force essentiality. Application of the methods requires some effort by the military services and hence, represents a long range solution to the problem. The benefits achievable are significant. The development and application of meaningful measurements of item, contingency and force essentiality will not only allow for a balanced allocation of war reserve funds, but will also provide a basis for more meaningful measurements of combat readiness. It is recommended that the methods described in this report be further developed, tested and evaluated. Some computer programs which would facilitate the tests of the proposed methods already exist.

In examining the current war reserve selection criteria and methods a number of additional problem areas were identified which can be resolved by short range solutions. The major problem areas include the following:

1. Scope of Selection Policy and Criteria

There is an inconsistency among and within the military services in defining items as war reserves. There is no uniform distinction made between prepositioned war reserves and general mobilization reserves. Current selection criteria are not always applied to prepositioned war reserves. There is no uniform method for computing either prepositioned war reserve requirements or general mobilization reserve requirements.

2. Application of D-P Day Concept

The principal reason for providing war reserves is to support a combat operation for a period of time (D-P Day) until wartime resupply can be accomplished. There is an inconsistency in applying the D-P Day concept within and among the military services. The methods for determining the D-P time are non-uniform and in many cases imprecise.

3. Interchangeable and Substitutable Considerations

War reserve requirements are often computed separately for items that are interchangeable or substitutable. This leads to inflated requirements when wartime consumption rates based on an entire group of interchangeable items are applied to each specific item in the group when computing war reserve requirements.

4. Funding Constraints

A major problem, after war reserve items have been selected and requirements computed, is that the funds necessary to procure all of the required war reserve stock are not available. No uniform method currently exists for allocating available funds for war reserves within or among the military services. Achieving an effective balance of war reserve funds requires uniformity in defining war reserves, computing war reserve requirements, and measuring item essentiality. Uniform definitions of war reserves and uniform methods of computing requirements can be established at the present time. Uniform measurements of item essentiality, as stated earlier, requires a long range solution.

5. Cost/Effectiveness Trade-Off Considerations

There are a number of areas where cost/effectiveness trade-offs should be considered in determining the range and depth of war reserve requirements. The most significant of these is the evaluation of different D-P times for a given item, at different item procurement costs. In most cases the D-P time can be decreased by paying a higher unit cost for the quantity of items procured during the D-P period. If a given item is currently being supplied to the military for peacetime consumption when D-Day occurs, it is likely that wartime consumption rates could be satisfied in a period of time less than the peacetime procurement time by utilizing peacetime production sources on an overtime or extra shift basis. This may result in a higher unit cost for the initial wartime quantities required, but require a considerably less investment in war reserve stock. An analysis of this type of trade-off suggests that potential savings could

be very substantial. The report presents a simple method for making the trade-off analysis. The cost and time data must be obtained from current production sources. The process of obtaining such data will, in itself, greatly improve wartime production planning.

Another area where cost/effectiveness trade-offs should be considered is in determining the requirements for end items versus the requirements for repair parts. Current practices are to compute requirements for all essential repair parts for a given essential end item. In many cases this is unnecessary because some of the repair parts are required only for depot level repair and the depot repair cycle may be longer than the D-P time for that specific repair part. In such cases it may be better to provide more end items.

With the exception of those problem areas dealing with the need for measurements of item, contingency, and component force essentiality, improvements can be achieved quickly in the above problem areas by establishing a number of supplementary policies to the current war reserve selection criteria directive (DoD Directive 3005.5). The study concludes that the war reserve selection criteria presently contained in DoD Directive 3005.5 cannot be significantly improved by more definitive criteria of a qualitative nature. The study further concludes that the most significant improvements in the selection of war reserve material can be achieved by establishing uniform policies and methods for computing war reserve requirements.

Fourteen supplementary policies are recommended as a short range solution to the problem areas described in the report. Twelve of the supplementary policies are aimed at providing a uniform definition of war reserve materiel and establishing uniform methods for computing requirements. Two of the supplementary policies are aimed at providing an effective method of allocating available funds for war reserves and encouraging the military services to consider item, contingency and component force essentiality in determining fund allocations.

A long range recommendation is made to initiate in-depth study, with the cooperation of the military services, to further develop, test and evaluate the methods described in the report for establishing quantitative measurements of item essentiality, contingency essentiality and component force essentiality.

I. INTRODUCTION

A. BACKGROUND

Each of the military services and the Defense Supply Agency stock certain items of equipment and equipment components as war reserves. War reserve stocks are intended to provide a reserve of equipment and equipment components necessary to sustain a combat operation until resupply can be accomplished. War reserve stocks are not intended to be used for peacetime operations, although such use is allowed under certain conditions.

Criteria for the selection of war reserve items are currently provided by DoD Directive 3005.5, dated November 8, 1965. The criteria are basically of two types. The first are affirmative type criteria which, when applied, result in the selection of items as war reserves. The second are negative type criteria which, when applied, result in excluding items as war reserves. Although the negative type criteria are more definitive than the affirmative type, both types are general in nature and, hence, subject to wide interpretation and judgment. The results of applying the current criteria are: 1) many items are selected as war reserves which may not be required; 2) an inconsistency exists among the types of items that are selected by different military commands and services; and 3) the criteria do not provide a basis for allocating available funds for war reserve stock within or among the military services.

B. OBJECTIVES

The purpose of this task, as stated in LMI Task 72-4, is

> "....to develop more definitive criteria to apply in identifying war reserve stock, and to develop recommended DoD policies which prescribe requirements for using such criteria. The criteria developed should be sufficiently definitive to: a) provide a basis for identifying war reserve items and stock uniformly among the military departments; and b) allow for an effective and balanced allocation of war reserve funds among the military departments and various commodities within the military departments."[1]

Three principal objectives were specified in the task order. The first objective was to identify current methods used by the military departments in determining which items to stock as war reserves. At the suggestion of OASD(I&L) personnel responsible for war reserve policies, LMI concentrated the study efforts on the methods applied by the Army and Navy. Unlike the Army and Navy, the Air Force concepts regarding contingent combat engagements have not resulted in establishing significant war reserve requirements. This is caused primarily by past Air Force concepts that anticipated combat contingencies to be of short duration.

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[1] LMI Task 72-4, "Identification of War Reserve Stock," 23 July 1971. A copy of the Task is included in this report as Appendix 1.

A second objective was to identify major problem areas resulting from the application of current policies and methods for selecting war reserve items and to recommend short and long range solutions.

The third objective was to develop and analyze alternative methods and criteria for identifying war reserve requirements and to recommend the most appropriate methods and criteria to apply. In accomplishing this objective, LMI found that effective criteria for selecting an item for war reserve stockage were not entirely independent of the quantity of the item required for war reserve. Thus, alternative methods considered included methods for computing quantity requirements.

II. FINDINGS AND ANALYSIS

Chapter II of the report is organized in three major sections corresponding to the three principal objectives of the study. Section A, Present Situation, describes the types and approximate quantities of war reserves currently stocked, and the methods, procedures, and criteria currently applied by the military services in determining war reserve requirements. Section B, Major Problem Areas, identifies and proposes solutions to specific problems which are associated with the application of current methods, procedures, and selection criteria. Section C, Alternative Solutions, examines the principal problem of improving the selection of war reserve materiel. It is concluded in Section C that a better disciplined and uniform method of computing war reserve requirements is a more fruitful approach than the development of more definitive selection criteria of a qualitative nature. It is further concluded that measurements of item essentiality, contingency essentiality, and component force essentiality are necessary to establish war reserve requirements in a cost/effective manner. Several approaches leading to the development of such measurements are described in Section C.

A. PRESENT SITUATION

1. War Reserves Defined

LMI found different interpretations to exist among the military services with regard to what materiel should be considered as war reserves. The Office of the Secretary of Defense and the Office of the Joint Chiefs of Staff (JCS) are currently in the process of clarifying the definition of war reserves.

JCS Publication Number 1, which is currently under revision, provides a definition of "War Reserve Materiel Requirement." The JCS definition being considered is long and awkward, but it does provide a basic rationale for establishing the need for war reserves. Actually, the JCS definition embodies most of the significant elements necessary to determine the required quantities of war reserve stock. The revised definition under consideration is as follows:

> "War Reserve Materiel Requirement - The quantity of an item, in addition to the M-Day force materiel requirement required to be in the military supply system on M-Day in order to support planned mobilization, to expand the materiel pipeline, and to sustain in training, combat and combat support operations, as applicable, the approved U.S. force structure (active and reserve) and those Allied forces designated for U.S. materiel support, through the period described for war materiel planning purposes. It is the quantity by which the war materiel requirement exceeds the sum of the M-Day force materiel requirement plus the quantity of the item which can be acquired (procured or returned and overhauled), by orders placed on or before M-Day, during the period for which wartime requirements have been computed, with this quantity being adjusted as necessary after considering the essentiality of the

item to the overall mission, modernization, storage characteristics, and costs of storage and maintenance."[1]

The Army defines war reserves more succinctly as "....stocks of materiel acquired in peacetime to meet increased military requirements consequent to an outbreak of war. These reserves are intended to provide support to sustain operations until resupply can be accomplished."[2]

Regardless of the definition applied, there are several conditions which are intrinsic to the concept of war reserves and to the requirements for materiel to qualify as a war reserve item. First, a potential combat mission or operation must be defined. The combat missions are described in JCS contingency plans or in operational projects designated by the military departments.

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[1]The "M-Day" referred to in the JCS definition is generally interpreted to be the day that a requirement to mobilize forces is evident or the day that a decision to mobilize forces is made. The term "D-Day" is frequently used in connection with war reserve definitions, policies and procedures. D-Day is generally interpreted to mean the day that hostilities or initial combat operations begin. For the purpose of this study, there is little reason to draw a distinction between M-Day and D-Day. Therefore, the term D-Day will be used in this report to indicate the beginning of hostilities or the day the decision to mobilize is made, whichever comes first in a given situation.

[2]Army Regulation 11-8, "Principles, Objectives and Policies of the Army Logistic System," August 1970, paragraph 3-20.

Second, the war reserve materiel must be essential to the success of the combat mission or the logistics support for the combat mission. Third, the materiel must either be required to equip initially a combat or combat support force, or it must be the type of equipment that is consumed, destroyed or damaged during the combat mission. If the latter condition prevails, the materiel will have a wartime consumption which requires resupply of the materiel in order to sustain the combat operation. Finally, wartime consumption rates must be specified as well as the time required to sustain the combat operation until resupply can be accomplished. That time is generally referred to as the D-P time; D being the time at which the combat operation begins, and P being the time at which the procurement and delivery of materiel meets the demands of wartime consumption.

In defining war reserves, one additional issue requires some discussion. Is there a difference between the equipment provided for the peacetime force structure and equipment provided for war reserves? This question is particularly bothersome when addressing principal end items such as aircraft, ships, and tanks. Such items are seldom thought of as war reserves. Yet, it might be argued that the entire peacetime force structure is, in fact, a war reserve since the equipment is primarily intended for combat should the occasion arise. The JCS definition draws a distinction between the wartime force and the peacetime force. The peacetime force is the approved force structure acquired and maintained in an operationally ready condition during peacetime. Although the primary purpose of the peacetime force is to be ready for combat, it also serves

other purposes such as test and evaluation of equipment and tactics, and training of personnel. The wartime force is a planned enlargement of the peacetime force after hostilities begin. The difference between the wartime materiel requirements and the peacetime materiel requirements, until resupply of materiel to meet wartime requirements is accomplished, represents the war reserve requirements.

Two points should be made clear at the beginning of this report. First, the approved force structure for peacetime operations and the materiel required to support the approved peacetime force structure are not considered to be war reserves. Second, war reserves are provided to sustain a contingent combat operation only until resupply can be accomplished, and as such, are consumed when a contingency occurs for which they are provided.

There are two principal types of war reserves - prepositioned and general mobilization. These are discussed below.

a. Prepositioned War Reserves - JCS Publication Number 1 defines the prepositioned war reserve requirement as "....that portion of the war reserve materiel requirement which approved plans dictate be positioned prior to hostilities at or near the point of planned use or issue to the user, to insure timely support of a specific project or designated force during the initial phase of war, pending arrival of replenishment shipments."

b. General Mobilization War Reserves - General mobilization war reserves are the materiel required to initially equip a major wartime force structure and to sustain the major combat operations until resupply is accomplished, less the prepositioned war reserve stock. In other words, the general mobilization war reserve requirement is that portion of the war reserve materiel requirement not provided for by prepositioned war reserves. The reason for subtracting prepositioned war reserves is that the specific contingencies or operational projects for which prepositioned war reserves are stocked are considered to be included in major combat contingencies where an all-out mobilization of forces is required.

There are three major contingencies for which general mobilization war reserve requirements are calculated. The three major contingencies are derived from two basic threats of war and include the possibility that both may occur at the same time. One threat is related to Europe and the other to the Far East. The scenarios for the three major contingencies are prepared jointly by OASD (Systems Analysis) and JCS. In addition, OSD provides the services with annual logistics guidance which aids in the calculation of war reserve requirements.

The OSD guidance to the services regarding war reserves is generally in the form of the Secretary of Defense Five-Year Fiscal Plan. This fiscal guidance is normally in the form of a memorandum. The guidance begins with certain requirements and assumptions made by the National Security Council. Next, JCS and OSD jointly prepare the Logistics Guidance Memorandum for

service comment. The services review the memorandum and return their comments to the Secretary of Defense, who then considers the service comments and publishes the Fiscal Guidance Memorandum. (OASD (Systems Analysis), OASD (Comptroller), and OASD (I&L) are all involved in reviewing the service comments and developing the Fiscal Guidance Package.

2. War Reserve Requirements and Assets

Some indication as to the quantities and value of war reserve requirements and assets will be helpful in understanding the magnitude of the problems associated with the selection of war reserve materiel. Unfortunately, the total value of war reserves in the Department of Defense is not readily available, and the figure cannot be easily extrapolated. There are several reasons why the value of war reserve assets is not easily quantified across the DoD. First, there is an inconsistency among the military services in identifying assets which are considered war reserves. For instance, some using units retain supply assets which are considered prepositioned war reserves, while other using units retain assets for wartime consumption but do not identify them as war reserves. Another reason is that summary reports for the DoD Supply System Inventories do not identify war reserve assets as such. The bulk of war reserve assets are included in a category called "Approved Force Acquisition" in the Department of Defense Comptroller's Report on "Real and Personal Property of the

Department of Defense."[1] However, based on the data provided in the Comptroller's report and, assuming that 30% of the value of the supply system inventory are war reserve assets, the following approximation can be made.[2]

- Value of all weapons and other military equipment in use . . . . . $105.8 Billion
- Value of supply system inventory (including stock fund) . . . . . $ 46.5 Billion
  - -- Value of war reserves in supply system inventory . . . . . $ 13.9 Billion
- Value of stock fund inventories . . . $ 9.4 Billion
  - -- Value of war reserves in stock fund inventories . . . . . $ 2.8 Billion

The $46.5 billion of supply system inventories indicated above does not include supply items which have been issued

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[1] "Real and Personal Property of the Department of Defense" is a report prepared by the OASD (Comptroller) and submitted annually to the President and the Congress. This is the only document LMI could identify which summarizes the Supply System Inventories for the Department of Defense. LMI reviewed the report issued as of 30 June 1971, in order to obtain some indication of the value of war reserve assets in relation to the total Supply System Inventories. The values reflected in the report for long-life and major equipment, such as ships and aircraft, represent acquisition cost. The value of items other than major equipment in supply system inventories is generally based upon standard prices representing replacement or estimated purchase price.

[2] A review of the current value of stratified stocks in the Army Stock Fund indicates that the value of war reserve assets constitute 30% of the total value. While similar data for the total Supply System Inventory of the DoD could not be found, it seems reasonable to assume that the ratio would be approximately the same.

to consuming military units such as divisions, air-wings, and ships. Supply items held by such using units, beyond that required for peacetime consumption, represent an additional amount of war reserves.

The above approximated value of the war reserve assets does not represent the required value as currently calculated, but rather the value of the assets which are applied against current requirements. The requirements are considerably greater than the actual materiel on hand, particularly for stock fund items. For example, Figure 1 shows the relationship of war reserve materiel assets and requirements to the total value of the Army Stock Fund Inventory. It should be noted that while the value of war reserve materiel is almost 78% of the peacetime operating stock value, the war reserve assets represent less than 47% of the currently calculated requirement. This would suggest that either the war reserve requirements are highly overestimated, or that the supply system inventories are not sufficient to meet the major wartime emergency. In either event, a uniform method of calculating war reserve requirements needs to be adopted which will provide decision makers with a greater degree of confidence in the results of the calculation and provide a basis for effective allocation of funds when total requirements cannot be filled.

War reserve requirements are calculated for numerous line items of supply by each of the military services and DSA. Figure 2 indicates the approximate number of line items for which war reserve calculations are made by each DoD component.

Figure 1

APPROXIMATE VALUE OF WAR RESERVE STOCK
FOR ARMY STOCK FUND

(In $ Millions)

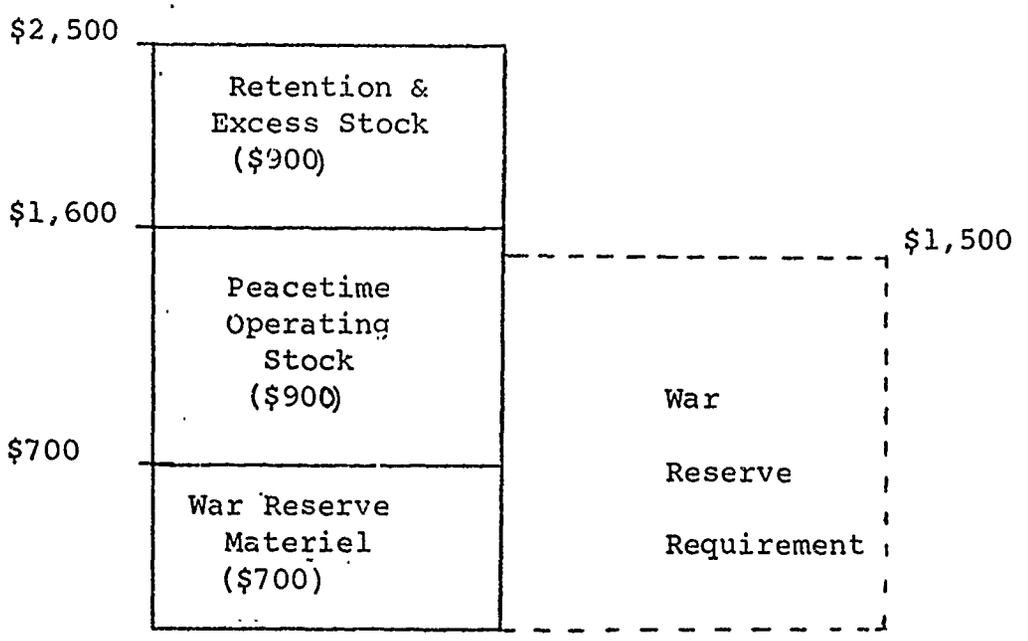
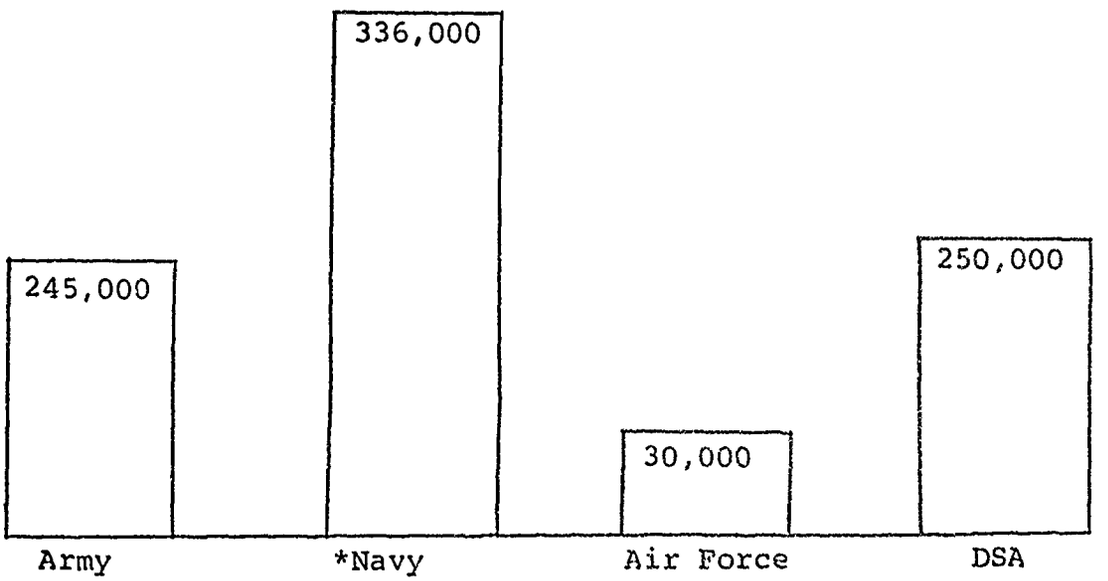


Figure 2

NUMBER OF LINE ITEMS FOR WHICH
WAR RESERVE CALCULATIONS ARE MADE



*Included 57,000 Marine Corps Items

3. War Reserve Selection Policies

Each of the military services and DSA follow DoD policies in selecting items that are stocked as war reserves. The DoD policies are in the form of selection criteria which are contained in DoD Directive 3005.5.[1] As mentioned earlier, there are two types of criteria - affirmative and negative. The affirmative type specifies the selection of items to stock as war reserves if, under combat conditions, an item meets any of the following specific criteria:

1. Items which would be required for the survival of personnel.
2. Items essential for the operational effectiveness of combat, combat support, and combat service support forces.
3. Items essential for the operational effectiveness of the logistics system in support of combat forces.
4. Items, the lack of which would render inoperative or seriously impair the operational effectiveness of an essential equipment or weapon system.
5. Items essential for the support of Civil Affairs and Prisoners of War.

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[1] DoD Directive 3005.5, "Criteria for Selection of Mobilization Reserve Items," November 8, 1965.

6. Items required in support of a sudden call-up of reserve forces which are essential for initially equipping, housing and training those reserve forces approved by Secretary of Defense logistics guidance.

All of the preceding criteria are general in nature and subject to the judgments of the military services and theater commanders. No distinction is drawn between prepositioned war reserves and general mobilization war reserves, with the possible exception of criterion 6, which is aimed at a general mobilization requirement. Several significant elements which dictate the need for war reserves are omitted. The current criteria do not specify that the selection of an item as a war reserve must be in response to a specific approved contingency plan, either major or minor, with the possible exception of criterion 6. The current criteria do not emphasize the essentiality of an item during the initial combat period until wartime resupply is accomplished. In other words, the essentiality of an item during the D-P time period is not specified as a selection criterion. The current criteria do not emphasize the essentiality of an item based on its contribution to sustaining a specific combat mission or maintaining a specific combat force. The current criteria do not specifically require consideration to be given to the maintenance plan, under combat conditions, or to the time required to enlarge the peacetime force to a wartime force necessary to meet a given contingency. All of these omissions impede the selection of war reserve items and the calculation of war reserve requirements in a consistent manner among and within the military services.

All of the affirmative criteria explicitly or implicitly address the essentiality of an item as the principal criterion for item selection for war reserve stockage. Yet, no degrees of item essentiality are suggested within or among the criteria provided. Thus, all items selected by current criteria tend to be treated as though they have equal essentiality.

Criterion number 1 specifies that items will be selected for war reserve stockage if they are required for the survival of personnel. Application of this criterion results in the selection of a wide range of items from gas masks, decontamination agents and survival kits to sunglasses and insect repellants. There would appear to be a considerable difference in the essentiality of gas masks and survival kits, on the one hand, and sunglasses and insect repellants on the other hand.

Criteria 2, 3, and 4 specify the selection of items for war reserve stockage which are"essential for operational effectiveness" of combat forces, the logistics system in support of combat forces, and essential equipment or weapons. Items selected by these criteria range from major weapons and their components to binoculars and wrist watches. Again, there would appear to be a wide range in the degree of item essentiality associated with such items.

Criterion 6 allows items to be selected as war reserves if they are essential for initially equipping, housing and training reserve forces suddenly called-up to meet a major contingency.

Here, item essentiality has a different orientation from that implied by the first four criteria. In the first four criteria, item essentiality is oriented toward a combat mission where the forces are already equipped with certain basic materiel. In criterion 6, item essentiality is oriented toward the initial issue of materiel, and includes such things as weapons, survival equipment and clothing on the one hand, and dusting mops, wiping rags, laundry soap and toilet soap on the other hand. There is certainly a difference in item essentiality among these items, and between items selected in response to criterion 6 and criteria 1-4. Moreover, there is an apparent difference in item essentiality with regard to time. Items held as war reserves for a combat force which might become engaged in actual combat on a moment's notice are more essential than items held for a potential combat force which must be activated, conditioned, trained and deployed before actual combat engagement.

The negative type criteria provided by DoD Directive 3005.5 prohibit the selection of items to be stocked as war reserves based on the following criteria:

1. Items solely for comfort, convenience or morale.
2. Items not currently stocked which are planned for procurement after the assumed M-Day.
3. Items which are or will become non-standard within the approved planning period, except when the end item supported can be used as an acceptable substitute for a standard item which will not be available.

4. Items which can be readily fabricated in the field with the tools and bulk materiel normally available.

5. Subsistence items except for operational rations.

6. Items normally available from commercial sources in sufficient quantities to meet war reserve military demands. Exceptions will be permitted when military considerations indicate that commercial type items must be prepositioned prior to the assumed M-Day, e.g., to support a sudden call-up of reserve forces.

7. Items which have a short shelf life. Certain short shelf life items can be selected when overriding military effectiveness considerations prevail.

The negative type criteria are quite definitive with the exception perhaps of criteria 3 and 6. Application of criterion 3 requires consideration of the current force structure and its materiel requirements, materiel obsolescence, and some indication of the relative operational effectiveness of an obsolescent item compared with a new or standard item. Intrinsic to these considerations are all of the aspects of item essentiality as related to the affirmative type criteria. Item essentiality considerations are also associated with criterion 6. In addition, application of criterion 6 requires some assessment of the availability of commercial materiel, particularly during a period of general mobilization.

In addition to the selection criteria prescribed in DoD Directive 3005.5, OSD provides the military services with annual Secretary of Defense logistics guidance for the calculation of war reserve requirements. Current logistics guidance provides the military services with three scenarios for major war contingencies. Based on the three scenarios each military service must specify: 1) the application of the proposed force structure to each scenario including pre-M-Day force deployment and post M-Day deployment schedules; and 2) the derivation of the M-Day inventory objectives which, when combined with production acceleration capability, will provide complete materiel support to the proposed U.S. and designated allied forces.

Each military service is requested to submit for OSD review certain data in support of secondary end item war reserve requirements.[1] The requested data are as follows:

1. Planned period of combat support (e.g., six months or D-Day to P-Day).
2. Type of consumption (e.g., training, sustained combat, intense combat) and description of the basis for derivation of consumption rates.

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[1] An end item is a weapon or piece of equipment that performs a military function by itself, such as an aircraft, ship, rifle, radio, canteen or binoculars. End items which are highly complex, very costly or perform major military functions are designated as principal end items. All other end items are designated as secondary end items.

3. Planned levels of supply in different segments of the distribution system (e.g., number of days of stocks at organizational level, number of days in transit, number of days at intermediate stock points, number of days in wholesale depots).

4. Training/support base force factors (e.g., assumed new accession rate, assumed terms of service and tour lengths).

5. Peculiarities of engagement, such as climate, terrain, and tactics, which impact item selection (e.g., what part of the force is provided arctic gear?)

6. Maintenance philosophy during D-Day to P-Day period.

7. Rationale for prepositioned stock requirements by theater.

8. Asset application.

9. Method of estimating initial issue shortages.

The required data above may be submitted in narrative form to describe how each data item was considered in determining secondary item war reserve requirements.

4. War Reserve Selection Procedures

a. Army

The Army's war reserve selection process begins with the development of the Mobilization Reserve Stockage List (MORSL). The MORSL is a consolidated list of principal and

secondary end items authorized for war reserve stockage for worldwide use. The items are selected by the Commanding General, U.S. Continental Army Command (USCONARC) and by overseas Theater Commanders, subject to approval by Headquarters, Department of the Army. The items are selected in accordance with policies and criteria provided by AR 11-8,[1] part of which implements DoD Directive 3005.5. The selection criteria for war reserves provided in AR 11-8 are identical to the criteria provided by DoD Directive 3005.5.

The MORSL is revised and published annually. The latest issue contains 3,314 line items identified by commodity manager, type of funding and the command for which stockage of the item is authorized.[2] Table 1 provides a summary of the number of line items identified in the MORSL by commodity manager and type of funding; Table 2 provides a summary of the number of line items by commodity manager and by the command for which stockage is authorized.

The second step in the Army's war reserve selection process is to identify essential components and repair parts required to support the principal and secondary end items listed in the MORSL. The assignment of item essentiality codes for repair parts is the responsibility of the Army activity responsible for furnishing initial materiel support for the system or

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[1] AR 11-8, "Principles, Objectives and Policies of the Army Logistics System," August 1970.

[2] A line item includes all Federal stock numbered items possessing the same functional capability.

TABLE 1

SUMMARY OF MOBILIZATION RESERVE STOCKAGE LIST
BY COMMODITY MANAGER AND TYPE FUNDING

U.S. ARMY COMMODITY MANAGER	Number of Line Items Stocked as War Reserves by Type of Funding				
	Total	PEMA	STOCK	O&MA	NO FUND INDICATED
U.S. Army Mobility Equipment Cmd. (Engineer, QM MHE & SPV, Transp. Marine & Rail type)	618	480	120	1	17
U.S. Army Medical Materiel Agency (Medical type items)	7	-	7	-	-
Director of Army Transp., ODCSLOG (General purpose commercial vehicles)	-	-	-	-	-
U.S. Army Support Center, Richmond (General supply type items)	177	-	128	3	46
U.S. Army Support Center, Philadelphia (Clothing & textile type items)	262	-	206	-	56
U.S. Army Electronics Cmd. (Electronic type items)	997	754	158	-	85
U.S. Army Aviation Systems Cmd. (Air transp. & air delivery, QM type items)	196	114	61	-	21
U.S. Army Tank-Automotive Cmd. (Vehicles & other combat type)	116	115	-	-	1
U.S. Army Missile Cmd. (Guided missile type items)	162	160	-	-	2
U.S. Army Weapons Cmd. (Weapons, combat vehicles, fire control & associated equipment type items)	238	126	111	-	1
U.S. Army Ammunition Procurement & Supply Agency (CBR type items, demolition sets, nuclear weapons training items & related test & handling equip. & ammunition)	261	206	50	-	5
U.S. Army Petroleum Center (Petroleum type products)	260	-	13	-	247
U.S. Army Area Support Cmd, Chicago (Subsistence supplies)	6	-	1	-	5
U.S. Army Strategic Communications Cmd. COMSEC Directorate (COMSEC equipment)	12	-	12	-	-
Unidentified	2	2	-	-	-
TOTALS	3314	1957	867	4	486

TABLE 2

SUMMARY OF MOBILIZATION RESERVE STOCKAGE LIST
BY COMMODITY MANAGER AND COMMAND

U.S. ARMY COMMODITY MANAGER	Number of Line Items Stocked as War Reserves by Command					
	CON	ALA	EUR	SET	PAC	SOU
U.S. Army Mobility Equipment Cmd. (Engineer, QM MHE & SVP, Transp. Marine & Rail type)	516	213	383	105	455	135
U.S. Army Medical Materiel Agency (Medical type items)	3	3	7	3	7	3
Director of Army Transp., ODCSLOG (General purpose commercial vehicles)	-	-	-	-	-	-
U.S. Army Support Center Richmond (General supply type items)	172	98	55	35	106	91
U.S. Army Support Center, Philadelphia (Clothing & textile type items)	261	227	202	46	228	174
U.S. Army Electronics Cmd. (Electronic type items)	447	375	581	155	778	431
U.S. Army Aviation Systems Cmd. (Air transp. & air delivery, QM type items)	179	99	123	35	123	96
U.S. Army Tank-Automotive Cmd. (Vehicles & other combat type)	98	74	107	40	96	52
U.S. Army Missile Cmd. (Guided missile type items)	162	-	-	-	-	-
U.S. Army Weapons Cmd. (Weapons, combat vehicles, fire control & associated equipment type items)	208	92	161	28	155	84
U.S. Army Ammunition Procurement & Supply Agency (CBR type items, demolition sets, nuclear weapons training items & related test & handling equip. & ammunition)	210	171	237	110	216	155
U.S. Army Petroleum Center (Petroleum type products)	175	97	151	81	209	119
U.S. Army Area Support Cmd., Chicago (Subsistence supplies)	6	1	6	6	2	2
U.S. Army Strategic Communications Cmd. COMSEC Directorate (COMSEC equipment)	11	7	12	6	12	7
Unidentified	-	-	2	-	1	1
TOTALS	2448	1457	2027	650	2388	1350

NOTE: CON - United States Continental Army Command
ALA - United States Army Alaska
EUR - United States Army Europe
SET - Southern Europe, Turkey and North Africa
PAC - United States Army Pacific
SOU - United States Army Southern Command

end item for which the repair parts are required. Current policy regarding essentiality coding is provided by AR 700-18,[1] which describes the essentiality of a repair part as the degree to which the lack of the part would affect the ability of the system or end item to perform its assigned mission. AR 700-18 specifies three essentiality codes described as follows:

Code	Definition
H	A support item or a repair part whose lack renders the supported item or end item inoperable.
S	A support item or repair part not qualified for classification as Code "H" but which is needed to-- (1) Satisfy legal, climatic or other requirement peculiar to the planned operational environment of the supported item. (2) Minimize or eliminate a safety hazard to the operator or crew of the supported item. (3) Preclude the creation of a hazardous condition within the vicinity of operations of the supported item. (4) Prevent the impairment of or the temporary reduction in effectiveness of operation of the supported item because of a lack of servicing type items such as oil and air filter elements or filters.
L	A support item or repair part not qualified for placement in Essentiality Code "H" or "S".

[1] AR 700-18, "Repair Parts, Special Tools and Test Equipment Allocation and Allowances."

AR 700-18 specifies that the assignment of essentiality code "H" or "S" indicates that the support item so coded is qualified for stockage in war reserves under the criteria prescribed in DoD Directive 3005.5 (affirmative criterion number 4, as indicated in this report on page 21).

The next step is to establish prepositioned war reserve requirements (PWRR). Prepositioned war reserve requirements are established for overseas theaters and for continental U.S. (CONUS). PWRR for overseas theaters fall into one of two categories: 1) those stocks required to sustain combat operations for a major conflict from D-Day until normal resupply can be provided; and 2) those stocks required to meet Department of the Army (DA) approved operational projects in support of specific contingency plans. Requirements calculated for the first category are based on a designated level of supply authorized by Secretary of Defense logistics guidance and are generally expressed in terms of number of days of supply. Requirements for the second category are determined for each DA approved operational project and are reviewed annually to determine continued essentiality of both the projects and the individual items. A list of all DA approved operational projects is published semiannually.

Prepositioned war reserve requirements for CONUS depots are also calculated against certain Army designated purpose codes. These purpose codes include contingency support stocks which are back-up stocks for theater commands, approved operational projects, and activation of reserve units.

The next step is to calculate the total war reserve materiel requirements for each of the major war contingencies described by the design scenarios provided by Secretary of Defense Annual Logistics Guidance. These calculations are made by the responsible commodity class manager for each Federal Stock Numbered end item which falls into any line item category indicated in the MORSL. Calculations are also made for each component or repair part that has been identified as essential.

At this point, the commodity class manager determines the estimated quantity of peacetime materiel on hand at the time of the assumed D-Day. In addition, some commodity class managers determine the quantity of materiel that can be introduced into the pipeline during the D-P Day time period by acquisition of new materiel and by repair of damaged or failed materiel.

The General Mobilization Reserve Requirements are then determined by subtracting from the total war reserve materiel requirements, the sum of the prepositioned war reserve materiel, the peacetime materiel, the new materiel acquired during D-P Day, and the damaged materiel recovered during D-P Day.

After the general mobilization reserve requirement for a given item is determined, one final step remains before the selection process is complete. This final step is a screening out of war reserve items based on calculated requirements of low quantity, low value or both. For instance, the Army

Aviation Systems Command excludes an item from general mobilization reserve if the computed requirement is less than 1 or if the value of the computed requirement is less than $20.00. The Army Mobility Equipment Command (MECOM), on the other hand, establishes a prepositioned war reserve requirement to the nearest whole number if the computed quantity is greater than ½ regardless of the value. If the value of the general mobilization reserve requirement for a given item is less than $5,000, MECOM establishes requirements only for prepositioned war reserves, but provides a 6-month peacetime safety level of stock for the item.

b. Navy

The Navy's war reserve selection process is generally similar to the Army's process, but there are some significant differences. The principal Navy document which identifies specific war reserve items is the Fleet Iss e Requirements List (FIRL). However, unlike the Army's MORSL, e FIRL includes items other than those which qualify as war reserves under the criteria listed in DoD Directive 3005.5.

The Navy war reserve selection process actually begins with the development of Shipboard Allowance Lists. Shipboard Allowance Lists describe and establish allowed quantities of materiel authorized a Navy ship for self-support. The materiel specified in shipboard allowances represents the first echelon of support. Among the criteria applied in developing shipboard allowance lists are: 1) the item must have predicted usage of at least one unit in 90 days aboard a ship; 2) the number of

units required during a 90-day period will be predicated on combat consumption rates. Application of the second criterion results in stocking prepositioned war reserves aboard a ship to the ext .it . t the combat consumption rates exceed peacetime consu ption ra es. However, the Navy does not recognize such materiel st cked aboard ship as prepositioned war reserves.

After the shipboard allowance list is established at the first echelon of support, the Mobile Logistics Support Force (MLSF) Load Lists are developed as the second echelon of support. The MLSF includes the total materiel requirements for supply support of deployed forces and of forces to be deployed to meet operational projects. These materiel requirements are determined through the development of the Fleet Issue Requirements List (FIRL) and the Tender/Repair Ship Load Lists (TLL). The range and depth of the materiel identified in the FIRL and the TLL and authorized afloat/ashore supplements thereto are considered prepositioned war reserves for the MLSF. Fleet Issue Load Lists (FILL) are developed to reflect that portion of the total FIRL that is to be loaded in an individual ship. That portion of the FIRL that is not covered by specific FILLs is prepositioned ashore at overseas or CONUS bases.

Like the Army, the Navy determines prepositioned war reserve requirements and general mobilization reserve requirements. In establishing prepositioned war reserve requirements, the Navy recognizes two principal categories of war reserves: a) those which support special projects specifically approved by the Chief of Naval Operations; and b) those which generally support Navy operations.

There are no specific criteria applied to the selection of items for prepositioned war reserve stockage. The items selected are generated from a list of functional components including associated list of materiel indicated by the responsible command for the component such as NAVORD, NAVSHIPS, etc. These functional components are identified in NAVSUP Publication 28, "Advanced Base Functional Components." The individual line item requirements are established by the responsible Inventory Control Point (ICP). The Fleet Material Support Office (FMSO) determines all tender and repair shipboard loads except for the fleet ballistic missile ships. Prepositioned war reserve requirements are calculated every six months for approximately 43 specific projects approved by the Chief of Naval Operations.

There are several problems associated with the selection of prepositioned war reserve items and the computation of the requirements. The range and depth of prepositioned war reserves are continually changing due to the changes that constantly occur in shipboard load lists; the activation of new ships, and the deactivation or retirement of existing ships. Another problem has to do with the location of prepositioned war reserves for a specific operational project which is stocked ashore. If the home base of a ship for which the stock is held is moved from one port to another, the stock is also moved. This results in a continual relocation of stock from one base to another. There seems to be little justification for continually shipping such stock from one location to another since it could be air lifted in a matter of days should an emergency situation occur.[1] Still another problem is that locally procured items are not

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[1]The location of war reserve materiel and the mode of transportation used during wartime are two areas which are outside the scope of this study and which might well be given further study.

excluded from the selection of prepositioned war reserve items. Thus, requirements computations are often made for such items by the ICP only to be deleted later by the specific base where the items are stocked.

Policies and criteria for the selection of general mobilization reserve items are provided by OPNAV Instruction 4080.2B[1] and NAVSUP Instruction 4440.47I.[2] Implementing procedures are specified in "Supply System Design Specifications (SSDS) for Uniform Inventory Control Program (UICP), Application B, Operation 20." The selection criteria specified in these documents are basically the same criteria specified in DoD Directive 3005.5. Several additional criteria of the exclusion type are specified in the SSDS/UICP procedures. These are:

- Locally controlled items unless specifically required by the inventory manager concerned.
- Items for which only a peacetime program requirement has been established.
- Items supporting only ships transferred to the Maritime Administration.
- Items which have a production leadtime of less than six months and for which the gross system demand or the numerical stockage objective is less than $10.00.

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[1] OPNAV Inst. 4080.2B, "Policies and Criteria Governing the Selection and Procurement of Items for Mobilization Reserve Stock."

[2] NAVSUP Inst. 4440.47I, "Requirement Determination and Stratification of Assets," 8 July 1970.

The Navy implementing procedures expound on two of the DoD selection criteria. Commercial items normally available are defined to include all items with a production leadtime less than three months and items with a production leadtime less than six months if the item is produced solely to an industrial association or Federal specification rather than a proprietary or military specification. The short shelf life criterion is further defined to be less than twelve months.

It should be noted again that the selection criteria apply only to determining the range and depth of general mobilization reserve and not to prepositioned war reserves. In selecting items for general mobilization reserves, the Navy process begins with the lists of essential items designated on approved and up-to-date allowance lists (shipboard and FIRL), initial outfitting lists, and load lists (TLL and FILL). Repair parts and supporting materiel are included if necessary to keep essential equipment and weapons operable. These items are then subjected to the selection criteria and excluded accordingly. Wartime requirements are then computed for all remaining items. Estimated prepositioned war reserve assets are subtracted from the wartime materiel requirements to get the general mobilization reserve requirement.

In computing general mobilization reserve requirements, consideration is not given to the number of ships in the reserve fleet or the time required to activate a ship if a major war occurs.

In addition to applying the selection criteria, some of the Navy inventory managers exclude entire Federal Supply Classes from war reserve consideration. For instance, the Fleet Material Support Office (FMSO) excludes some 87 Federal Supply Classes from war reserve computations. This appears to be a very expedient method for reducing the number of war reserve computations which have to be made. It would further appear that many other Federal Supply Classes could be added to the FMSO list and applied to all military services without jeopardizing the ability to support a major war. The list of Federal Supply Classes eliminated by FMSO during General Mobilization Reserve computations is included in this report as Appendix 2. FMSO manages approximately 900,000 Federal Stock Numbered (FSN) items, or about 75% of the total stock funded items in the Navy. There are approximately 140,000 FSNs managed by FMSO which have prepositioned war reserve requirements and about 90,000 FSNs which have General Mobilization Reserve requirements.

c. Defense Supply Agency

The Defense Supply Agency establishes war reserve requirements for all military users of the items managed by DSA. However, each military service selects the range of items requiring war reserve stock which it has determined to be essential. DSA computes the quantity of items required as war reserves taking into consideration the wartime demands of all users. DSA applies a $5,000 minimum value requirement for

general mobilization reserve. In other words, if the value of the general mobilization reserve requirement for a given item is less than $5,000, the item is excluded from war reserve stockage. According to the Army, this minimum value was applied for the first time in the 1971 computations which resulted in reducing the number of Army Stock Fund items requiring war reserves and managed by DSA from approximately 64,000 items to approximately 6,400 items.

B. MAJOR PROBLEM AREAS

The overall DoD objective of stocking war reserve materiel is to provide a readily accessible and effectively balanced source of essential materiel which, together with peacetime materiel stocks, will sustain potential combat engagements until wartime resupply can be accomplished. There are a number of problem areas associated with the application of present policies and criteria for the selection of war reserve materiel which impede full achievement of the overall DoD objective. The present policies and criteria do not necessarily create the problems, but rather allow the problems to exist. Present policies and criteria need to be modified or supplemented to provide the type of guidance necessary to achieve effective solutions in the major problem areas discussed in the following paragraphs of this section of the report.

1. Measurements of Item Essentiality

Perhaps the most difficult problem associated with the provisioning of war reserves is to determine which items are really essential to the success of a given mission. Every

military professional is acutely aware of the adage "for the want of a nail the battle was lost," but the perplexing problem is to determine which items represent the nail. In the case of repair parts or components, item essentiality is generally established by asking the question "would failure or lack of the component or repair part result in failure of the end item to perform its intended function?" Sometimes this question is not easily answered, particularly when failure of a given component may not actually render the end item inoperative but, rather, will degrade its performance. In most cases, item essentiality with regard to a component or repair part can be determined by engineering analysis. In cases where component failure results in degradation of performance, however, item essentiality is dependent on such things as the environment in which the end item is used, the nature of the mission, the extent of the performance degradation, and the required functional interface between the end item in question and other end items involved in the mission. In short, item essentiality must be determined by applying the judgments of experienced field commanders.

The judgments of experienced field commanders are utilized now in developing operational plans to meet various contingencies, in allocating certain forces to the operational plans, in developing Tables of Organization and Equipment (TOE) and allowance lists for various combat forces in the service, and in developing requirements for future weapons systems. The problem is, how can the best judgments of our best tacticians and field commanders be better recognized and utilized by the logistician? Some consistent method for quantifying these judgments is needed to provide a basis for item essentiality

measurements. Without a common yardstick for measuring item essentiality optimal cost/effective logistics support is impossible, and achievement of a balanced allocation of funds for war reserve materiel within and among the military services is, at best, left to chance.

Present policies and criteria for the selection of war reserve materiel do not require the use of common measurements of item essentiality mainly because there are none. Such measurements need to be developed and tested. Several approaches to the problem are discussed in Section C of this report. Development and test of the proposed methods for establishing item essentiality measurements, however, will take some time and effort on the part of the military services. Present policies should be modified now to encourage the military services to expend the required effort.

2. Measurements of Contingency Essentiality

Item essentiality varies with the mission which the items are intended to support. In other words, the same item may have a greater essentiality when used to meet one contingency than it does when used to meet another contingency. Therefore, common measurements of item essentiality must be coupled with common measurements of contingency essentiality. To put it another way, meaningful measurements of item essentiality must be based on specific or general military operations which require the use of a variety of equipment to accomplish the mission. This means that some common yardstick for quantifying contingency or mission essentiality is required.

Measurements of contingency essentiality should include at least two principal elements: 1) relative importance of the contingency and, 2) probability of occurrence. Each of these elements might, in turn, be based on a number of sub-elements. For instance, relative importance might include military, political and economic ramifications. Military ramifications might, in turn, include such things as loss of a strategic operating base, cut-off of required supply routes, or loss of a supply depot or ammunition dump.

Each of the military services develops contingency plans and operational plans based on the best intelligence and experience available; and each service assigns priorities to the plans. The objective here is to capture the results of military judgments in a common quantifiable way so that optimal logistics support can be provided to meet military needs. A method for achieving this objective is developed in Section C of this report.

3. Measurements of Component Force Essentiality

Item essentiality not only varies with the mission for which the items are intended, but also with the component force structure that utilizes the item in pursuit of the mission. For instance, an infantry company may be authorized a certain number of personnel canteens - one for each man in the company; an aerial support company may also be authorized a certain number

of personnel canteens - maybe 10 or 12 for the entire company for emergency use. Because of the nature of the component force structure and its intended mission, the canteen would undoubtedly be more essential to the infantry company than to the aerial support company.

When the military planners develop a contingency plan, a number of different type component forces may be designated to meet the contingency. They may all have equal essentiality to the success of the mission, or some may be more essential than others. Those that have high essentiality are given top priority for supply support. Judgments regarding component force essentiality are made now by the military services, and like contingencies, common measurements of essentiality need to be applied by logistics support planners. In summary, to determine the relative significance of war reserve items it is necessary to develop and apply common measurements of item essentiality, contingency or mission essentiality, and component force essentiality. This can be achieved by quantifying the best judgments of experienced military personnel. A method for quantifying such judgments is discussed in Section C of the report.

4. Scope of Selection Policy and Criteria

The war reserve selection process consists of two principal operations. First is the identification of candidate items for war reserve stockage. This is accomplished by applying the qualitative selection criteria provided by DoD Directive 3005.5, or by determining the type of materiel required to meet a given contingency plan or operational project. The second

operation is to determine war reserve quantity requirements for the candidate items selected in the first operation. If the quantity requirements are not sufficiently large for a given item, the item may be dropped from the war reserve list. Since the selection of an item for war reserve stockage is dependent on both qualitative criteria and quantity requirements and since some of the qualitative criteria are, themselves, dependent on quantity requirements, war reserve selection policy should include both selection criteria and computational requirements. Present policy only includes qualitative selection criteria.

There are significant interfaces between the computation of requirements for prepositioned war reserves and for general mobilization reserves. Prepositioned war reserves are normally computed for specific operational projects or contingency plans, although some general mobilization reserves may also be prepositioned. The prepositioned location may be such as to provide support for only one specific component force; whereas another location may be chosen which will allow the same materiel to support several different forces and several different contingencies. General mobilization reserves are determined by subtracting the prepositioned war reserves from the total war reserve materiel requirement. Unless the items are selected by the same set of criteria, there is no basis for the computational interfaces, and there is no opportunity to make cost/effectiveness trade-offs.

A major problem is that the present policy and criteria contained in DoD Directive 3005.5 are not always applied to prepositioned war reserves. There should be consistency

between prepositioned war reserve selection and general mobilization reserve selection. Item essentiality considerations should apply equally to both categories.

Present policies should be supplemented to specifically require that war reserve selection criteria contained in DoD Directive 3005.5 be applied to both prepositioned war reserves and general mobilization reserves. In addition, present policies should prescribe a simple but fundamental method for computing both prepositioned war reserve requirements and general mobilization reserve requirements. Such a method is recommended in Chapter III, Conclusions and Recommendations, and simple mathematical formulae are proposed in Appendix 4.

5. Application of D-Day to P-Day Concept

The principal reason for providing war reserves is to support a combat operation for a period of time until wartime resupply can be accomplished. This period of time is normally referred to as the D-P time. The concept is applicable to the computation of requirements for both major and minor contingencies. In the case of minor contingencies, the D-P time might be the resupply time for a given component force from the next higher supply echelon. In the case of major contingencies, the D-P time might include the time to gear up production facilities to meet wartime consumption. In either case, war reserve policy should specify the application of the D-P time in determining war reserve requirements, and should provide some guidance in estimating the D-P time.

Current methods for estimating D-P time among and within the military services are imprecise and non-uniform. In some cases D-P time is assumed to be a constant 90-days, 120-days or 6 months for all items considered by the inventory manager. In other cases D-P time is estimated for each item by using the latest production lead time for that item and adding one month administrative lead time.

6. Interchangeable and Substitutable Items

Discussions with various inventory managers indicate that war reserve requirements are often computed for a number of items that are interchangeable or substitutable. This can lead to inflated requirements depending on how wartime consumption rates are applied. In order to avoid inflated requirements, computational requirements, particularly for general mobilization reserves, should be made for groups of items that are interchangeable or substitutable. War reserve selection policy should require consideration of interchangeability and substitutability characteristics of candidate war reserve items. Selection criteria should require, where possible, identification of one or two preferred items in each group of interchangeable or substitutable items. The preferred items should then be designated as those for which war reserve requirements will be established.

7. Funding Constraints

A major problem, after war reserve items have been selected and requirements computed, is that the funds necessary

to procure all of the required war reserve stock are not available. Funding constraints can occur with regard to prepositioned war reserves or to general mobilization reserves, although they are more likely to occur with regard to the latter. It was noted earlier in the report that the Army Stock Fund currently suffers an $800 million deficit in war reserve stock compared with the computed requirements of $1500 million (see Figure 1, page 20). Table 3 shows a comparison of prepositioned war reserve requirements and prepositioned war reserve stock for a number of different type Navy retail items carried in the Navy Stock Account. It should be noted that only about 30% of the requirements ashore are filled while 100% of the requirements afloat are filled.

Since funding constraints have always occurred in the past and can be expected to occur in the future, some consistent method of allocating available funds for both prepositioned war reserves and general mobilization reserves should be provided by OSD as guidance to military inventory managers.

8. Cost/Effectiveness Trade-Off Considerations

There are a number of areas where cost/effectiveness trade-offs should be considered in determining the range and depth of war reserve requirements. One area to consider is the stocking of an end item as war reserves versus the stocking of repair parts for the end item. Current practices are to compute requirements for all essential repair parts for a given essential end item. In many cases this is unnecessary because some of the repair parts are required only for depot level repair and the depot repair cycle for the end item may be longer than the D-P time for the repair part. In such cases it may be better to provide more end items.

TABLE 3

COMPARISON OF PREPOSITIONED WAR RESERVE REQUIREMENTS (PWRR) VS. PREPOSITIONED WAR RESERVE STOCK (PWRS) FOR VARIOUS CATEGORIES OF NAVY RETAIL ITEMS CARRIED IN THE NAVY STOCK ACCOUNT

($THOUSANDS)

CODE	DESCRIPTION	PWRR	PWRS	DEFICIT
9A	Parts peculiar to combat and tactical vehicles of Army design	$ 543	$ 45	$ 498
9C	Defense construction material.	18,704	4,051	14,653
9D/9U	Special occupational and environmental clothing and textiles, resale clothing and related items.	11,087	3,821	7,266
9G	Defense general material.	16,290	4,512	11,778
9E,F,I,J, V,W,Y	Consumable items under an interservice agreement.	292	21	271
9L	Defense medical material.	21,927	10,804	11,123
9M	Defense subsistence material.	17,718	7,061	10,657
9N	Defense electronic material.	14,941	596	14,345
9Q	Items accepted by the General Services Administration for support of Navy requirements.	7,277	1,625	5,652
9Z	Defense industrial material.	12,285	3,946	8,339
TOTAL ASHORE (All Categories)		$ 121,064	$ 36,482	$ 84,582
AFLOAT (All Categories)		$ 13,150	$ 13,150	-0-
GRAND TOTAL		$ 134,214	$ 49,632	$ 84,582

Another trade-off area is the location of war reserve stocks. The quantitative requirements may vary depending on the location of the war reserve materiel. This aspect of the problem was discussed earlier in the report on page 45.

Another area is the economic consideration for the pre-D-Day unit cost of materiel vs. post-D-Day unit cost. Some items are stocked as war reserves for purely economic reasons. An example of such a situation is given by the Army in the case of raincoats. The Army can procure raincoats during peacetime for about $15.00 per raincoat by allowing the industry to utilize its off-season production periods to manufacture Army raincoats and by providing the industry with pre-treated material. The Army estimates that general mobilization demands could be met in a reasonable D-P time period, but that the cost of a raincoat would probably be in the neighborhood of $40-$45.

The D-P time vs. the unit cost is an area which warrants consideration for all potential war reserve items which require a large amount of funds. In most cases the D-P time can be decreased by paying a higher unit cost for the quantity of items procured during the D-P period. After P-Day the unit cost should be the same regardless of the D-P time incurred. One way to decrease the D-P time is to utilize peacetime production sources on an overtime basis or by a 2nd or 3rd shift operation during the initial surge of wartime demands. This may result in a higher unit cost for the initial wartime quantities required, but require a considerably less investment in war reserve stock. The economic analysis can be made by comparing the cost of two

options. Option 1 is to procure and hold a quantity of war reserve stock (N_1) based on an estimated wartime consumption rate (r), a D-P time equal to the current procurement lead time (t_1), and a unit cost equal to the current procurement cost (U_1), so that $N_1=rt_1$. The cost (C_1) of procuring and holding N_1 units for t_d years may be approximated as follows:

$$C_1 \cong N_1U_1 \left[1 + k_o t_d \right]$$

where k_o = the holding cost expressed as a per cent of cost of the stock held per year, and

t_d = the number of years N_1 units are held before D-Day under option 1, and the number of years N_2 units are held before D-Day under option 2.

Option 2 is to procure and hold a quantity of war reserve stock (N_2) based on an estimated wartime consumption rate (r), and a D-P time (t_2) which is less than the current procurement lead time, so that $N_2 = rt_2$. However, under option 2, a higher unit cost (U_2) will be incurred when D-Day occurs in order to achieve the lower D-P time (t_2). The quantity of stock required at the higher unit cost is the difference between N_1 and N_2. The cost (C_2) associated with the second option may be approximated as follows:

$$C_2 \cong N_2U_1 \left[1 + k_o t_d \right] + \frac{(N_1-N_2)\ U_2}{(1+k_1)^{t_d}}$$

where k_1 = discount rate.

The savings resulting from computing war reserve requirements based on the shorter D-P time (t_2) is the difference between the cost of option 1 and the cost of option 2.

$$\text{Savings} = C_1 - C_2, \text{ or}$$

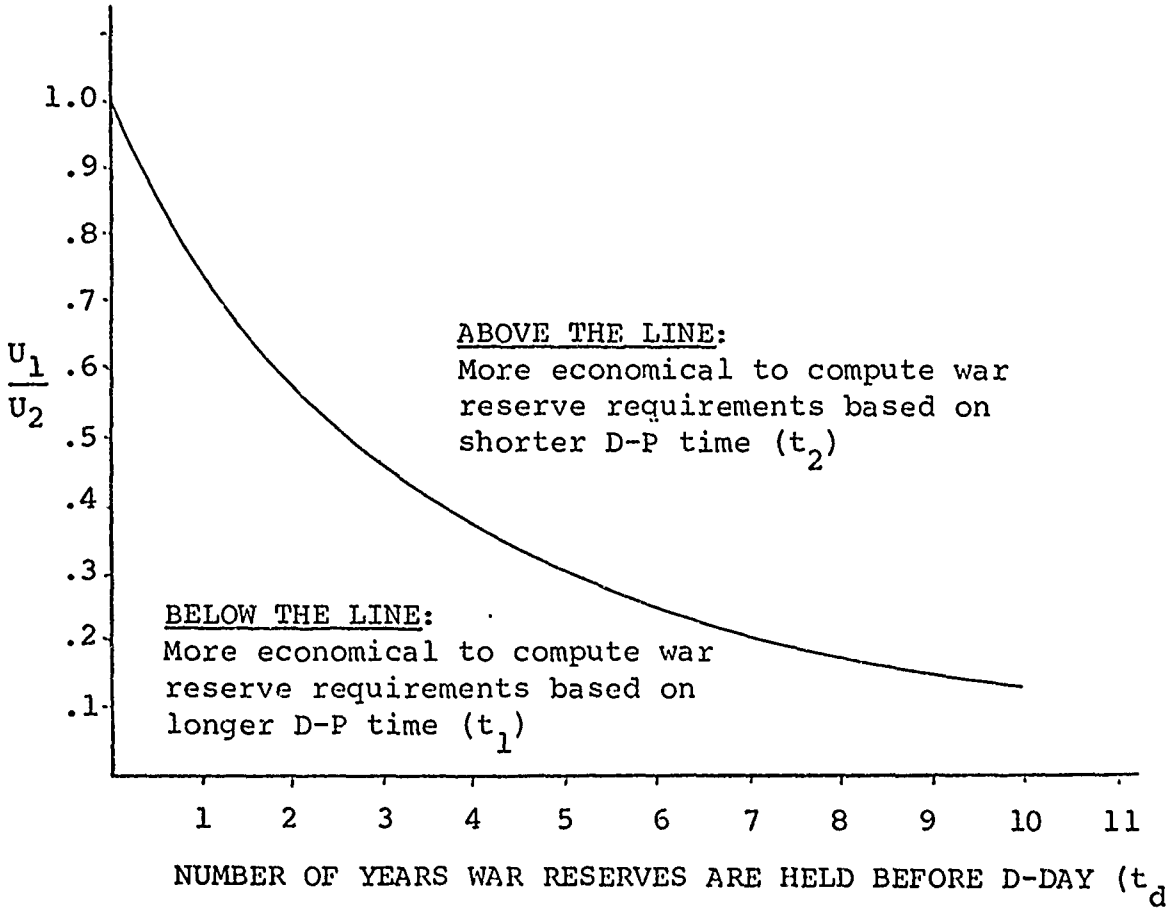
$$\text{Savings} = r(t_1 - t_2) \left[(1+k_o t_d)\, U_1 - \frac{U_2}{(1+k_1)^{t_d}} \right]$$

Whether a savings results from computing war reserve requirements based on the shorter D-P time is dependent principally upon the ratio of U_1 to U_2 and length of time the stock is held before D-Day (t_d). Figure 3 graphically depicts the "Break-Even" line at various values for the ratio $\frac{U_1}{U_2}$ and at various values for t_d, assuming $k_o = .2$ and $k_1 = .1$, which are realistic values for holding cost rate and discount rate respectively.

It is interesting to examine the savings equation above and speculate on the potential savings achievable. For instance, if $100 million of war reserve materiel currently required (less than 1% of total requirement) could be procured in 1/3 the presently planned D-P time at 150% of the current cost, and assuming a holding cost of 20% per year and a discount rate of 10%, then savings would result after about 1½ years; if D-Day were three years off, savings would be $31.4 million; if D-Day were 8 years off, savings would be $127 million. Actually, after 8 years, most materiel would be obsolete and the savings would be even larger.

FIGURE 3

ILLUSTRATION OF BREAK-EVEN POINT FOR WAR RESERVE REQUIREMENTS COMPUTED FOR ONE-THIRD SHORTER D-P TIME (FOR VARIOUS VALUES OF THE PERIOD WAR RESERVES ARE HELD BEFORE D-DAY)



(Holding cost = 20% per year; Discount rate = 10% per year)

C. ALTERNATIVE SOLUTIONS

A number of alternative solutions for improving the selection of war reserve materiel and establishing quantity requirements were examined during the study. Insofar as selecting the items which qualify for war reserve stockage is concerned, there are two principal alternatives to consider. The first is to develop more definitive selection criteria of a qualitative nature than those currently provided by DoD Directive 3005.5. The second alternative is to accept the present selection criteria and develop supplementary policies for consistently computing war reserve requirements.

- More Definitive Qualitative Criteria

Consideration was given to developing war reserve selection criteria of a qualitative nature but in more definitive terms. For example, criteria currently stated in DoD Directive 3005.5, such as "Items essential for the operational effectiveness of combat, combat support and combat service support forces" might be expanded to include more specific criteria as follows:

a) Items which constitute an offensive striking force, the loss of which would prevent mission achievement.

b) Items which are required for essential communication between command and control headquarters and field combat forces.

c) Items which are required for surveillance of enemy forces.

d) Items which are required to provide the combat force mobility necessary for mission achievement.

Etc., etc., etc.

It will be noted that while such criteria as stated above may be more definitive than the more general statement currently prescribed in the directive - ".....essential for the operational effectiveness.....," the more definitive criteria do little to improve the selection process. There are three reasons why more definitive qualitative criteria, such as illustrated above, fail to significantly improve the selection of war reserve items.

First, the list of criteria would tend to be lengthy in order to cover all item categories that are essential for operational effectiveness. An extensive number of essential item categories is not necessarily a disadvantage and, in fact, would be an advantage if the item categories could be relatively weighted in significant terms. However, without relative weight among essential item categories the selection criteria would not be any more sensitive to item essentiality than is now the case; hence, more definitive criteria of this nature would only serve to make the selection process more complicated and would run the risk of omitting item categories which are truly essential to operational effectiveness.

A second reason for rejecting this approach is that the selection criteria still do not address the question of how essential a given type of item is within a specific category. For instance, items classified into the illustration category

d), of the preceding page, could include anything from a C-5A aircraft to a pair of combat boots, or perhaps even a pair of shoe laces.

Finally, this approach does not take into account the fact that item essentiality varies with the number of units of a given item which are available to perform a given mission. In other words, a given combat force may require 100 2½-ton trucks to transport men and materiel necessary to achieve a specific mission. The trucks are essential to the success of the mission, but if only 100 trucks are required, the 101st truck does not have the same essentiality as the 100th truck. However, if less than 50 trucks are available the risk of mission failure may be so great as to cause the mission to be cancelled.

- Uniform Computation of Requirements

One way to improve the selection of war reserve materiel is to better discipline the method for computing war reserve requirements. If war reserve requirements are determined by a consistent method within and among the military services, then there is some basis for allocating an appropriate balance of funds, provided some common measurement of item essentiality is applied in the method for determining requirements. Thus, the method of measuring different degrees of item essentiality remains as the key problem. Applying the present selection criteria contained in DoD Directive 3005.5 represents a first cut at solving the problem. The problem now is to develop some method of further categorizing or quantifying the essentiality of the items identified by applying the present

criteria. Many alternatives were considered. Three methods are presented for quantifying the essentiality of items within a specific component force which is required to perform a specific military mission. These methods are:

1) System network analysis;
2) Minimum/maximum equipment requirements analysis; and
3) Equal essentiality with balanced equipment allowance.

All of the three methods are considered worthy of trial and test. Each method is aimed at quantifying item essentiality to mission success. Each method can be applied to a specific type of component force with regard to realistic contingencies or missions required of that force. Thus, by sampling an appropriate number of forces and their respective potential missions, a common basis can be established for dealing with item essentiality. In each case the result of the exercise is a quantitative measurement of equally essential war reserve materiel required to maintain a balanced force structure until resupply can be accomplished. In each case the best judgments of military planners and commanders are brought to bear on the determination of war reserve requirements.

The three methods are described in the following three subsections. The fourth subsection, Contingency/Force Analysis, describes a method of evaluating the relative importance of various contingencies and component forces and can be applied to each of the three methods of quantifying item essentiality to mission success.

1. System Network Analysis

This method involves a systems engineering approach to the problem by modeling a component force in terms of the men and equipment required to perform its intended mission. Several models, which would allow this method to be tried without much difficulty, have already been developed and tested. Two models, the Network Reliability Assessment Model (NERAM), and the Integrated Support Requirements Model (INSURE), both developed by the General Electric Company, have been successfully applied in determining logistics requirements for several major military systems.[1] The NERAM and INSURE models are specifically structured to provide rather straightforward representations of very complex systems. The key to their successful application is the careful systems analysis used for relating the models to the system.

The Network Reliability Assessment Model (NERAM) Program and the INtegrated SUpport REquirements (INSURE) model developed by General Electric offer a means by which a system can be modeled complete with all serial and parallel characteristics. Their use provides a method by which inventory support items can be recommended based upon their criticality and contribution to the system's overall effectiveness.

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[1]The NERAM and INSURE models have been used successfully in determining the system availability and logistics support requirements for the SAFEGUARD Perimeter Acquisition Radar. The NERAM model and portions of INSURE form the basis for the SAFLOGTROM model used by the SAFEGUARD Logistics Command for determining the requirements for repair parts on SAFEGUARD. The General Electric Company has provided NERAM systems analysis for the major subsystems of SAFEGUARD. These models are also used in support of Navy Sonar programs and are planned for use on the Site Defense of Minuteman (SDM) Radar Prototype Demonstration.

War reserves are selected to support a combat force that may consist, for example, of rifle companies, heavy artillery units, tank battalions, etc. in the Army; submarines, carriers, destroyers, in the Navy; and Wings and squadrons in the Air Force. A collection of such combat elements would constitute what NERAM and INSURE address as a system. The war reserve inventory is intended to support the personnel and hardware that comprise the "system."

The combat units possess some level of redundant effectiveness. Tank battalions, for example, can make up for deficiencies in rifle companies or ground artillery can compensate for deficiencies in air support, etc. The integration of the forces into a system model would permit identification of all war reserves as inventory support items. The inventory items support the man-machine force elements introduced as the lowest level of the "system" modeled.

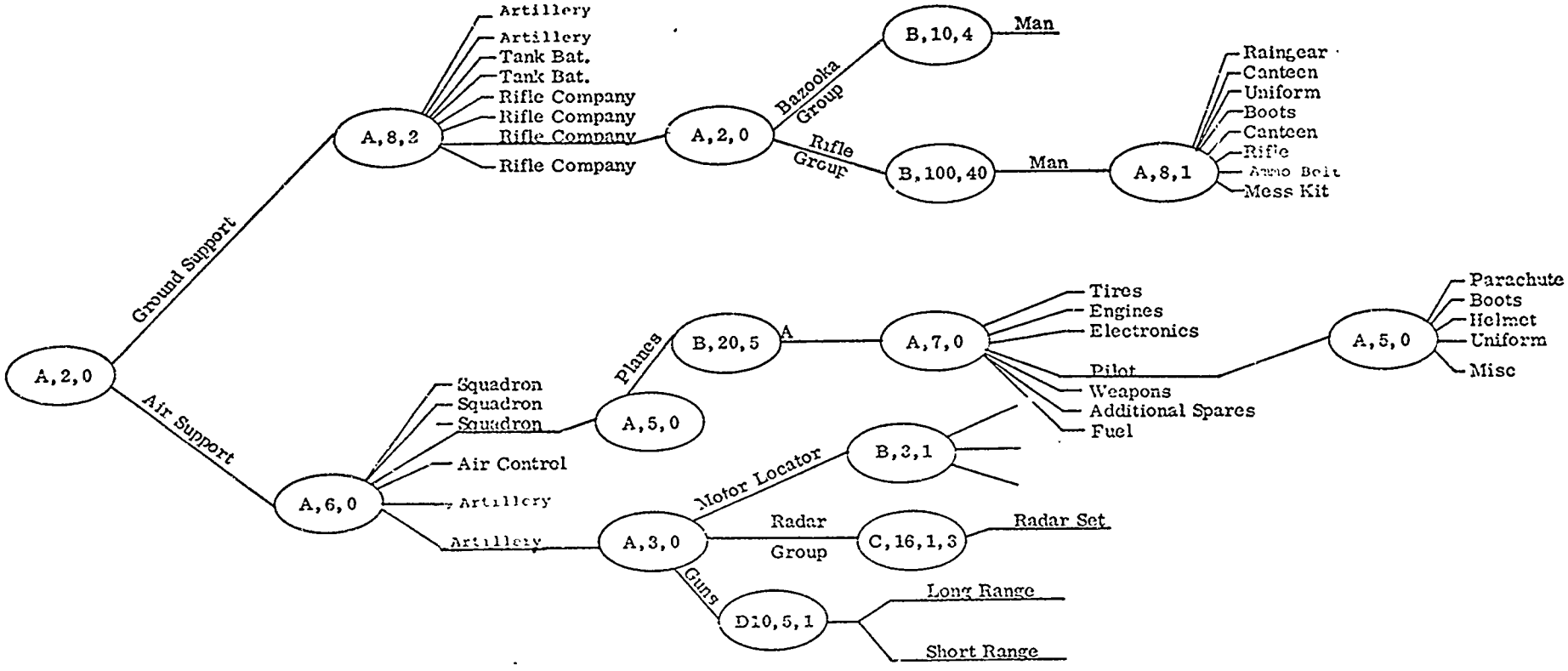
NERAM and INSURE provide the logistician with a tool capable of expressing system interactions and relationships in network form. The NERAM model is capable of assessing systems availability, or capability, whereas INSURE is capable of optimizing systems availability or capability.

To identify a combat force with these tools a simplified network might result, as depicted in Figure 4. The network has a tree-like appearance with a system level trunk, combat force units, personnel or tactical hardware for branches and the actual war reserve inventory items for leaves. The

Figure 4

PARTIAL SYSTEM NETWORK FOR WAR RESERVE SELECTION

EXPRESSED IN NERAM FORMAT



war reserve items are consumed during combat based on attrition, wear out, or failure rates, and are resupplied based on repair or replenishment time. Higher level system branches or nodes identify criticality through redundancy.

The system network employs A, B, C and D type nodes or branches. These are the network modeling blocks and they describe the system's interrelationships. The (A, n, m) node introduces n different parts or elements or men of which m can "fail" or be missing before the system is considered operationally ineffective or unable to perform its mission. The (B, n, m) node introduces n like elements of which m can fail. The (C, n, k, m) node introduces n like elements arranged circularly of which m can fail so long as k elements are working between any pair of consecutive failures, and the (Dn_1, n_2, m) node introduces a dual set of n_1 elements of one kind and n_2 elements of another where any m of the $n_1 + n_2$ population can fail. Details of the application of these submodels can be obtained from the Network Reliability Assessment Model Technical Information Series, R70 EMH19, April 1970, General Electric Company.

The models determine, for each war reserve item, the number of units required to maintain the system in an operational condition at some predetermined confidence level. The confidence level is similar to the system availability of a hardware system (i.e., the per cent of the time the system is available in an operational condition to perform its function). The system

availability or confidence level may be established as .90, .999 or .9999 for any given component force depending on the criticality of the force to the overall mission.

In determining the quantity of war reserve items required, the models examine the marginal improvement in system availability per dollar spent on war reserves. Thus, the model can optimize the war reserve inventory.

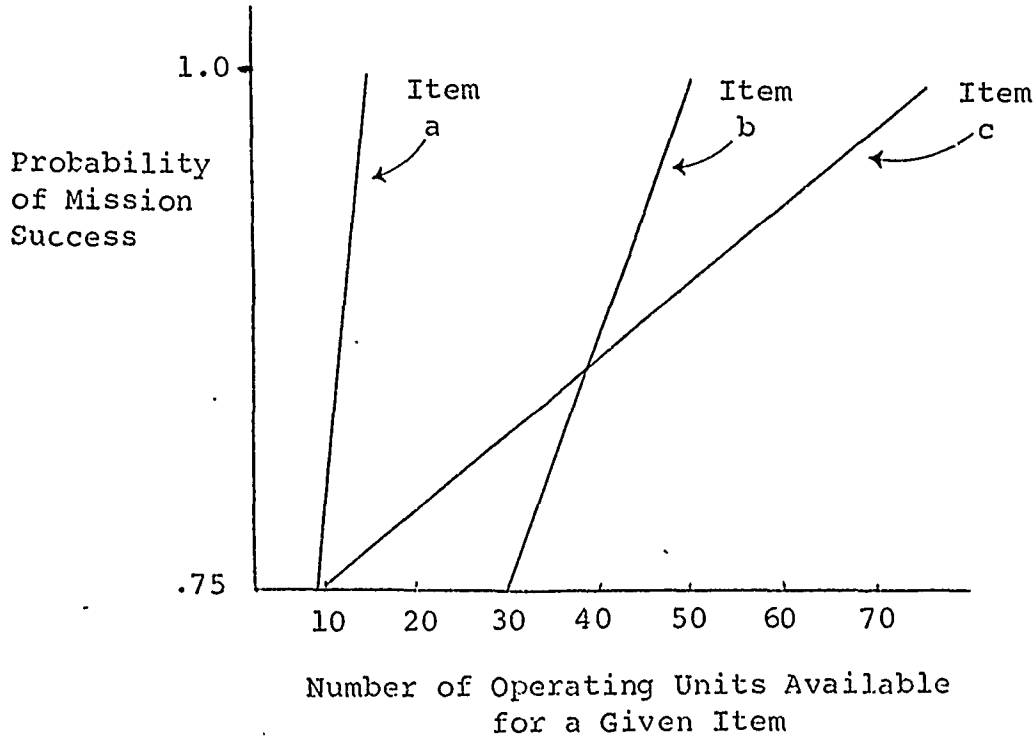
2. Minimum/Maximum Equipment Requirements Analysis

This method is similar to the system network analysis insofar as examining the interfaces among items of equipment are concerned. However, instead of determining the number of items which can "fail" before mission success is threatened, the minimum number of items required to achieve a specified probability of mission success, say 75% for instance, is determined. (In determining minimum requirements, interdependence among the items must be considered.) The maximum equipment requirement necessary to assure mission success is assumed to be the full allowance authorized for a given item. The minimum requirements are summed for a given item within a given component force to develop the relative essentialities among the items as illustrated in Figure 5. At a specified probability of mission success, say .9 or .95, the relative essentialities of items can be expressed in terms of number of operational units required to be available for combat. The quantity of war reserves required to sustain the combat operation can then be determined.

Figure 5

ILLUSTRATION OF MIN/MAX EQUIPMENT

REQUIREMENT ANALYSIS



3. Equal Essentiality with Balanced Equipment Allowance

This method assumes that the best military judgments have been exercised in developing equipment allowances for combat and combat support forces and in developing operational plans to meet a given contingency or a general battle mission. Based on this assumption, all items classified as essential to meet a given contingency will contribute equally to the success of the mission if maintained in the balanced quantities indicated by the allowance lists.

For example, suppose a given contingency required six essential items, a,b,c,d,e, and f, with 100, 200, 400, 50, 500 and 300 units, respectively, to be operationally available when the conflict begins. Each item in the required quantities indicated contributes equally to the success of the mission; and all together represent a balanced force. If the force is balanced by the unit quantities indicated, then a given per cent loss of the units required for any one item would be equally as harmful to mission success as the same per cent reduction or loss of any other item. In other words, a lack of 2 units of item a would have the same effect on the probability of mission success as loss of 4 units for item b, 8 units for item c, 1 unit for item d, 10 units for item e, and 6 units for item f.

Table 4 illustrates the number and value of war reserves required to maintain the balanced force for the above example with, and without, a budget constraint. The numbers of units required as war reserves are arbitrarily taken for illustration as 20% of the required force structure. Normally, war reserve requirements are not in the same ratios as the number of units required in the force structure because D-P time, etc., would be different.

However, if all these factors are considered in determining the number of units required as war reserves, then the resultant number of units for all items considered essential represents the quantities required to keep the force structure in balance. Therefore, if the funds available for war reserves

TABLE 4

ILLUSTRATION OF WAR RESERVE REQUIREMENTS FOR EQUAL ITEM ESSENTIALITY

Item	Number of units required in force	Number of units required as war reserves	Unit cost of item	Cost of required war reserves	Reduction in WR cost at 10% budget cut	Number of units cut for war reserves
a	100	20	$300	$ 6,000	$ 600	2
b	200	40	250	10,000	1,000	4
c	400	80	100	8,000	800	8
d	50	10	800	8,000	800	1
e	500	100	50	5,000	500	10
f	300	60	600	36,000	3,600	6
				$73,000	$7,300	

are only 90% of the required funds, then a straight 10% cut for all items would be in order and would maintain a balanced force structure.

4. Contingency/Force Analysis

Any one of the three methods described above can provide a basis for determining item essentiality for a given force structure with respect to a given contingency or combat mission. War reserve computations can then be made in terms of the number of units of an essential item required to sustain the given force structure until resupply can be accomplished. If insufficient funds are available to provide all of the war reserve materiel required, each method provides a basis for allocating the available funds within a given force structure and with respect to a given contingency or combat mission. The problem now is to integrate the war reserve requirements for a number of component forces into higher echelons of supply support so that an item manager will have some sound basis for determining the optimum balance among war reserve items. If all component forces and all contingencies or combat missions are equally important, then this becomes a simple task. However, if different component forces and different combat missions have different degrees of essentiality in contributing to the success of an overall mission, then some means of weighting the essentiality of the force and its mission must be developed.

This section of the report describes a method for developing measurements of contingency essentiality and measurements of component force essentiality. It should be noted at

the outset that the contingency/force analysis has two distinct applications. One application is for the analysis of specific minor contingencies or operational projects designated by JCS or each military service headquarters for which prepositioned war reserves are normally required. The second application is for any of the three major contingencies designated by JCS and OSD for which general mobilization reserves are normally required. The method is basically the same for either application except that in the second application the contingencies become the planned combat mission of the component force with regard to the overall major contingency.

Three factors are apparent in considering item essentiality with respect to the component force which requires the item, and the combat mission or contingency required of the component force. These are: 1) the relative probabilities that each of the different contingencies considered will occur; 2) the relative significance of the threat imposed by each contingency; and 3) the relative importance of various component forces which are deployed to meet the contingencies. The first two factors -- probability of occurrence and relative importance -- are discussed below under the heading of "Contingencies." The third factor is discussed subsequently under the heading of "Component Forces."

a. Contingencies - To assign weights to contingencies in a meaningful way it is necessary to first identify the various elements on which the weights depend. There are two principal elements: probability of occurrence and relative importance.

Probability of Occurrence

At first view it appears to be a difficult undertaking to assign a probability of occurrence to each contingency. However, such probabilities definitely enter in a certain way in military judgments. Perhaps the best way to consider such probabilities in a relative sense is to examine the contingencies in pairs. Assume, for instance, that a group of military experts is considering various contingencies that may possibly occur in the next five year period. The probability that two specific contingencies, A and B, are equally likely to occur, or that A is more likely than B, is not a difficult assessment to make. In some cases it may be possible to state that some particular contingency is 2 or 3 times as likely as another. It is reasonable to assume that expert judgments of this type can be obtained for every pair of contingencies.

Once pair-wise comparisons of contingencies have been made, the recorded judgments will serve as a basis for the next step, namely, to assign to each contingency an individual numerical weight such that for every pair of contingencies the ratio of their assigned weights reflects the judgment on the relative likelihood of occurrence.

The method of determining the desired weights is described in detail in Appendix 3. As for the meaning of the weights, it should be noted that they merely represent explicitly the information that is implicitly contained in the judgments,

assuming their correct interpretation. Thus, inasmuch as the weights intend to represent probabilities of occurrence, such representation is meant in a relative sense only. This means that the ratio of any two weights approximates the ratio of the associated probabilities. Assigning the weights does in no way presume or postulate an underlying set of probabilities in a physical sense.

In summary, the weights do not introduce any new information; they merely serve as a more usable form for recording the available information and a more effective form for using that information. For instance, if 50 contingencies are being considered, a set of 50 numerical weights forms a simpler basis for reasoning and computation than the set of 1225 verbal judgments obtained from comparison of pairs.

- Relative Importance

Weights representing the relative importance of meeting a given contingency are obtained from pair-wise comparisons of contingencies in the same way as the weights representing relative probability of occurrence. However, to insure meaningful application of these weights, it is necessary that the judgments on relative importance be completely independent from probability of occurrence. Otherwise the precise meaning of the two kinds of weights would be so obscured as to make them inapplicable.

One way of assuring the desired independence is to make each "relative importance" judgment under the assumption that the two contingencies under consideration have just occurred, and, hence, the judgment is definitely restricted to the question of their relative importance.

In many cases the question of relative importance may, in itself, be too complex to produce a realistically meaningful judgment. In other words, when comparing two contingencies, judgment on their relative importance may require simultaneous consideration of too many factors of differing natures. It may then be desirable to consider relative importance in terms of more specific properties. But here again it is essential to make certain that these judgments are independent in the sense that only the property under consideration enters the process of producing the judgment. The reason for splitting a judgment problem into a number of independent judgments, each relating to a single property, is to reduce the degree of complexity inherent in the overall judgment, in the hope of thereby enhancing the quality of the judgments.

The decision of when the splitting of a complex judgment into its elementary parts will really simplify the problem must be left to the experts charged with performing the judgments. It appears impossible to find a general rule for the purpose, except for the special case where the complex judgment would involve the cooperation of experts from different fields. In that case, grouping the underlying properties according to the fields of expertise may readily achieve a reduction of the problem, since independence here is almost automatic.

Examples of properties related to relative importance of contingencies and grouped according to fields of expertise are the economic, military, and political threats resulting from the inability to deal successfully with the contingencies. Hence, these and similar partitions are likely to bring better judgments.

The decision on <u>how</u> to partition the complex judgment problem is better left to the various experts in the underlying fields. Assume, for illustration purposes, that the judgments on relative importance have been made with respect to each of the three areas: a) economic threat; b) military threat; and c) political threat. Thus, three sets of judgments will have been obtained. For instance, comparison of the two contingencies A and B may have produced the following judgments: a) A and B are equally important when comparing their economic threats; b) A is twice as important as B, when comparing their military threats; and c) B is twice as important as A, when comparing their political threats. The mathematical procedure described in Appendix 3 will then be used to transform each of the three sets of judgments into three sets of numerical weights, one for each property or type of threat in this case.

Now, judgments reflecting the relative importance of each property will be made and transformed by the same mathematical procedure into numerical weights. The numerical weights of the properties and the numerical weights of the contingencies with respect to each property are then combined to produce a single set of numerical weights for the contingencies. Thus,

the end result is that to each individual contingency there is associated a single numerical weight reflecting the combined relative importance of economic, military and political threats, and termed the relative importance of that contingency.

In practice, the judgment on relative importance of contingencies will generally be divided into more than just the three properties used here for illustrative purposes. But the procedure will be the same, and the end result will be the same; for each contingency a single weight reflecting its relative importance.

Thus, what will have been achieved at this stage is the assignment of two numerical values to each contingency, one reflecting "probability of occurrence," the other reflecting "relative importance." These two numerical values or weights are then combined by assigning to each contingency the product of the two values associated with that contingency, and subsequently normalizing this set of values.

b. Component Forces - For each given contingency plan, which defines the contingency and determines the force structure to meet it, the weights (probability of occurrence and relative importance) assigned to the contingency are also assigned to the force structure as a whole. In case the various component forces, making up the total force structure, contribute in varying degrees to the success of the whole operation, it is desirable to determine their relative essentiality. The procedure in this case is the same as that used to determine

relative contingency essentiality. The judgments in this case are made by experienced field commanders, and subsequently transformed into numerical weights representing component force essentiality by the procedure described in Appendix 3.

5. Allocation of War Reserve Funds

War reserves are required to resupply some combat force structure engaged in a combat operation until wartime resupply can be accomplished on a continuing basis. Several principal factors must be known or assumed to determine the type and quantity of war reserves required for any given force structure. The factors are: 1) the plan for accomplishing the objective of the combat mission or contingency; 2) the composition of the force structure assigned to meet the contingency including the type and number of component forces and the equipment required by each component force; 3) the type and number of items within each component force which are essential to the successful operation of the force structure in meeting the contingency; 4) the time required to establish wartime resupply; and 5) item resupply requirements until wartime resupply is established.

Three methods have been described earlier in the report, any one of which can be applied by military planners in determining the equipment requirements of the force structure which must be maintained until wartime resupply can be accomplished. The methods are: 1) systems network analysis; 2) Min/Max equipment requirements analysis; and 3) equal essentiality with balanced equipment allowance. Once essential equipment requirements have been established, a method for computing specific item war

reserve requirements is proposed in Appendix 4. If sufficient funds are available to satisfy all war reserve requirements for all force structures and all contingencies, then the problem ends here. However, this has not been the case in the past and is not expected to be the case in the future. Therefore, item war reserve requirements must be evaluated with respect to relative essentialities of contingencies and forces in order to appropriately allocate available funds. A method for measuring relative essentialities of contingencies and component forces has been discussed and is described in detail in Appendix 3. Application of this method will result in two sets of weights--one which represents the relative essentialities among contingencies and the other which represents the relative essentialities of component forces assigned to any given contingency.

The problem now is to integrate item war reserve requirements with contingency essentiality weights and component force essentiality weights to provide a basis for allocating war reserve funds. This is accomplished in the following manner.

Suppose there are a number of distinct contingencies $j_1, j_2, \ldots j_k$ whose normalized essentiality weights are $w_1, w_2, \ldots w_k$ respectively. There are also a number of distinct force structures $F_1, F_2, \ldots F_m$, any one of which can be assigned to meet a distinct contingency. Any distinct force structure F assigned to a given contingency is assigned the same weight as the contingency. For instance, if force structure F_1 is assigned to contingency j_2, then the essentiality weight for F_1 is w_2.

If the same identical force structure F is assigned to a number of distinct contingencies $j_1, j_2, \ldots j_k$ whose normalized weights are $w_1, w_2, \ldots w_k$, then the weight Z assigned to F is defined as:

$$Z = w_1 + w_2 + \ldots + w_k$$

For instance, if force structure F_1 is assigned to contingencies j_1 and j_2, the Z_1, the essentiality weight of F_1, is equal to $w_1 + w_2$.

If war reserve funds are to be allocated only to force structures then the weight $Z_1, Z_2, \ldots Z_m$ would be determined and normalized, and the funds allocated on the basis of the normalized weights. However, each force structure F may have a number of component forces $f_1, f_2, \ldots f_m$ and each component force may have a relative essentiality weight with respect to F. If f_i is a component force of F, the weight ψ_i of f_i is f_i's essentiality to F, denoted by θ_i, times the weight of F which is Z. Hence,

$$\psi_i = \theta_i Z$$

If f_i is assigned to k distinct F's: $F_1, F_2, \ldots F_k$, then

$$\psi_i = \theta_{i1} Z_1 + \theta_{i2} Z_2 + \ldots + \theta_{ik} Z_k$$

where θ_{i1} = f_i's essentiality for F_1, θ_{i2} = f_i's essentiality for F_2, etc.

Table 5 provides an illustration. Suppose there are four different contingencies j_1, j_2, j_3 and j_4 whose essentiality weights are (.52), (.28), (.15), and (.05), respectively. Suppose that there are five different component forces f_1, f_2, ...f_5 such that f_1 and f_2 are assigned to contingency j_1; f_1 and f_3 to contingency j_2; f_4 and f_5 to contingency j_3; and f_1 and f_5 to contingency j_4. The relative component force essentialities with respect to each contingency are indicated in Table 5 by θ. Following the method described above, the overall essentiality weights for the component forces f_1, f_2, ...f_5 are (.441), (.208), (.196), (.075), and (.080) respectively.

- Method for Apportioning a Budget Cut

Now that component force essentiality weights and component force war reserve requirements have been determined, a method for allocating available funds will be described. This method will address how to apportion a budget cut if funds are not available to satisfy all war reserve requirements.

Assume the component forces are

$$f_1, f_2, \ldots, f_n;$$

their weights $\psi_1, \psi_2, \ldots, \psi_n$; and their war reserve requirements cost $c_1, c_2, \ldots, c_n$;

such that $c_1 + c_2 + \ldots + c_n = C$.

Now, assume that the amount of available funds is A where $A < C$; hence, a budget cut = C-A must be applied.

TABLE 5

ILLUSTRATION OF METHOD FOR DETERMINING OVERALL ESSENTIALITY WEIGHTS FOR FIVE DIFFERENT COMPONENT FORCES ASSIGNED TO FOUR DIFFERENT CONTINGENCIES

Component Forces	Contingencies				Relative Essentiality Weight of Component Force for all Contingencies (ψ_i)
	j_1	j_2	j_3	j_4	
	(θ_1) (w_1)	(θ_2) (w_2)	(θ_3) (w_3)	(θ_4) (w_4)	
f_1	(.6) (.52)	(.3) (.28)		(.9) (.05)	.441
f_2	(.4) (.52)				.208
f_3		(.7) (.28)			.196
f_4			(.5) (.15)		.075
f_5			(.5) (.15)	(.1) (.05)	.080

Since all war reserve requirements have been determined on the basis of being equally essential to the success of the operation, it can be assumed that a cut in c_1 by X% of c_1 and in c_2 by X% of c_2, ... etc., will cause a loss of α_1% in the effectiveness of f_1 of α_2% in the effectiveness of f_2, ... etc.

It is reasonable to assume that the α_1 are all equal, (i.e., $\alpha_1 = \alpha$ for all i) and that, for a cut of p% in each c_i the loss in effectiveness will be adequately approximated by $p\alpha$% for each f_i.

Since the f_i have been weighted with respect to their role in the overall security requirements, it is clear that the budget cut should be applied in such a way that the <u>weighted</u> loss in relative effectiveness is the same for each f_i.

Thus, if we cut c_i by p_i%, we want the products

$$\psi_1 \alpha p_1,\ \psi_2 \alpha p_2,\ \cdots, \psi_N \alpha p_N$$

all to be equal, and hence the products

$$\psi_1 p_1,\ \psi_2 p_2,\ \ldots,\ \psi_N p_N$$

all to be equal, say $\psi_i p_i = \lambda$ for all i.
Thus we have

(1) $\quad p_1 c_1 + p_2 c_2 + \ldots + p_n c_n = C\text{-}A \qquad$ (2) $\quad \psi_i p_i = \lambda$

Substituting $p_i = \dfrac{\lambda}{\psi_i}$ in (1), we obtain

$$\sum \frac{\lambda}{\psi_i} c_i = C\text{-}A$$

or

$$\lambda \sum \frac{c_i}{\psi_i} = C\text{-}A$$

hence, $\lambda = (C-A) \Big/ \sum \frac{c_i}{\psi_i}$

and $p_i = \frac{\lambda}{\psi_i}$

Thus, $p_i c_i = \lambda \frac{c_i}{\psi_i} = (C-A) \frac{\frac{c_i}{\psi_i}}{\sum \frac{c_i}{\psi_i}}$

which determines the cut $p_i c_i$ for each i. In other words, the cut C-A is apportioned to the various (f_i-budgets) c_i according to the weights $\frac{c_i}{\psi_i}$, and this is done simply by normalizing these weights to obtain the new, normalized weights

$$r_i = \frac{\frac{c_i}{\psi_i}}{\sum \frac{c_i}{\psi_i}}$$

and then obtain the cuts for the individual c_i:

$$r_1 (C-A), \quad r_2 (C-A), \quad \ldots, \quad r_n (C-A)$$

III. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

In the previous section of the report many conclusions have been drawn in describing the present situation, major problem areas and alternative solutions. Without repeating all of the findings and analyses previously discussed, the major conclusions are presented below, as concisely as possible under four general areas.

- Selection Criteria

  1. The war reserve selection criteria presently contained in DoD Directive 3005.5 cannot be significantly improved by more definitive criteria of a qualitative nature.

The present selection criteria, particularly the exclusion type, provide a good first cut at screening out items which do not warrant war reserve stockage. However, the criteria allow many other items to be stocked as war reserves which would appear to have marginal impact, at best, with regard to sustaining a combat engagement until resupply can be accomplished. The present criteria fail to screen out these items of marginal import principally because the criteria address all items which are essential or are required for operational effectiveness of forces, weapons and equipment, and the logistics support system. Under certain circumstances, almost any item can be shown to have some degree

of essentiality or to make some contribution to the operational effectiveness of the unit in which the item is used. Any selection criteria of a qualitative nature must allow for item essentiality judgments. Therefore, a more definitive criteria of a qualitative nature would also have to allow for item essentiality judgments and, hence, would do little to improve the present selection process. Some means is required for determining different degrees of item essentiality and item contribution to operational effectiveness.

Some minor improvements could be made, however, to present selection criteria of a quantitative nature. For instance, short shelf life could be defined as a specific period of time. In addition, at least 90-100 FSC classes could be specifically excluded from war reserve stockage.

- Computational Methods

  2. The most significant improvements in the selection of war reserve materiel can be achieved by establishing uniform policies and consistent methods for computing war reserve requirements.

Current OSD guidance regarding war reserve selection criteria needs to be supplemented by policies which: a) provide a uniform definition of war reserve materiel; b) establish consistent methods for computing requirements; and c) affect the allocation of available funds for satisfying requirements.

The war reserve definitions contained in JCS Publication Number 1 should provide the basis for policies and methods for computing war reserve requirements. However, certain policies need to be established to clarify war reserve categories, computational requirements for prepositioned and general mobilization war reserves, and cost/effectiveness trade-off requirements. Such policies are proposed in this Chapter of the report under "Recommendations."

Improved policies regarding computational requirements will provide a more pertinent range and depth of war reserve materiel than can be achieved by further selection criteria of a qualitative nature. For instance, establishing a policy which precludes stocking materiel as general mobilization reserves when the value of the computed requirements is less than $5,000 is a more effective way of screening out materiel which is likely to be available when required, than to try to develop more definitive criteria for commercially available items.

The selection of $5,000 as a minimum requirement for stocking general mobilization reserves is arbitrary, but it does seem to represent a conservative figure, provided the item has some peacetime demand. If the item has a peacetime demand, then production sources are available, and little risk is involved in procuring such a small amount of materiel during a normal D-P time of six months.

Any item that requires a general mobilization reserve in excess of $5,000 should be subjected to trade-off analyses for

a) different D-P time periods at corresponding procurement costs, and b) appropriate mix of end items and repair parts if the item in question is a repair part. Here again the $5,000 figure is arbitrary, but provides a reasonable minimum above which such trade-offs should be considered.

- Measurements of Item Essentiality

  3. Quantitative measurements of item essentiality are required to assure cost/effective logistics support for military engagements and to provide a basis for appropriate allocation of funds.

  4. Meaningful measurements of item essentiality must be based on three principal elements: a) an appropriate quantitative balance of items within a force which function together to meet a given contingency; b) the relative essentiality of contingencies considered; and c) the relative essentiality of forces used to meet the contingencies.

Military items of equipment contribute in different ways and to different degrees to the success of a mission depending on a variety of factors. These factors include such things as the nature of the item, itself, and its relative function with other items, the geographical location of the using unit, the tactics employed by the unit commander, and the strength and tactics employed by the opposing force. All of these factors are considered in structuring combat forces, determining the

type and quantity of equipment required, and in developing operational plans to perform general combat missions or meet specific contingencies. The equipment required for each force, the forces committed to each contingency, and the contingency plans are all based on the best judgments of experienced military planners and commanders. Such judgments represent the best source of information for developing measurements of item, contingency, and force essentiality. Three methods for examining item essentiality and subsequently developing quantified measurements are presented in this report. One method for developing contingency and force essentiality measurements is presented in the report. Each method depends on quantification of the judgments of experienced military planners and commanders, and all four should be tested, compared against each other, and evaluated for future use.

- Potential Benefits

  5. Uniform policies and consistent methods for computing war reserve requirements and the development of quantitative measurements of item essentiality will provide the military services with an invaluable tool for planning cost/effective logistics support to meet potential military engagements.

It is estimated that there are over $13 billion of war reserve materiel in the Department of Defense Supply System inventory. Providing the right mix of equipment and component

parts can have a profound effect on the ability to successfully sustain a major military engagement during the initial months of the conflict. The benefits derived from having the right equipment in the right quantities are immeasurable. Quantitative measurements of item essentiality can aid the military services in planning the most appropriate mix of war reserve materiel, and also provide a basis for improving tactical unit readiness measurements.

B. RECOMMENDATIONS

Two principal recommendations are made. The first contains fourteen supplementary policies and methods for computing war reserve requirements within and among the military services. The first recommendation provides a short-range solution to the problems described in the report. The second recommendation provides a longer-range solution and addresses the development of quantitative measurements of item, contingency, and component force essentiality.

Short-Range Solution

It is recommended that DoD Directive 3005.5 be revised to include the following supplementary policies regarding the selection of war reserve materiel, the computation of war reserve materiel requirements, and the allocation of funds to procure war reserve materiel. It is recommended that the selection criteria presently contained in DoD

Directive 3005.5 be retained and applied as a first cut in the selection process.

1. All materiel requirements laid on the supply system inventory at any supply support echelon which are not based upon support of the approved peacetime force at peacetime consumption rates will be designated as either prepositioned war reserve or general mobilization reserve requirements.

2. Prepositioned war reserve requirements will be determined for specific operational projects or contingency plans approved by JCS or the responsible military department. General mobilization reserve requirements will be determined for major contingencies specified by OSD/JCS scenarios.

3. All inventory stratifications of on-hand assets not directly attributable to the support of the approved peacetime force structure will be identified as either a) prepositioned war reserves or b) general mobilization reserves, or if the on-hand assets exceed the requirements of both a and b, the remainder will be identified as potential excess.

4. Each specific operational project or contingency plan which requires prepositioned war reserves will identify the specific items, quantities and value of the prepositioned war reserve materiel. Each inventory manager will identify prepositioned war reserves by operational project or contingency.

5. The selection criteria contained in DoD Directive 3005.5 will be applicable to both prepositioned war reserves and general mobilization war reserves.

6. General mobilization reserve requirements will be computed for groups of interchangeable and substitutable items and one Federal Stock Number in the group will be designated as preferred for general mobilization reserves. Total requirements for the group will be computed for the preferred item and no requirements will be established for the non-preferred items.

7. General mobilization reserve requirements for a specific item or group of interchangeable items which are computed to be less than $5,000 will not be authorized for war reserve stockage.

8. General mobilization reserve requirements for a specific item or group of interchangeable items which exceed $5,000 will be subjected to an analysis of different D-P time periods at corresponding procurement costs.

9. No war reserve requirement will be established for an item which is used only for depot level repair. Exceptions to this policy will be allowed if the D-P time for the repair part is greater than the normal peacetime depot repair cycle for any of the end items supported by the repair part.

10. No war reserve requirement will be established for an item which is used for repair of a specific end item if the end item is also stocked as a war reserve and the requirement for the repair part exceeds $5,000, unless the mix of end item requirements and repair part requirements is supported by a cost/effectiveness analysis.

11. General mobilization reserves may be stocked in an overseas theater or in the CONUS, or both. The requirements for overseas theaters and for CONUS will be identified separately but will not exceed the total general mobilization reserve requirement for a specific item or group of interchangeable items.

12. Computations for all war reserve requirements at any support level will be based on the following considerations. (Proposed formulae are provided in Appendix 4.)

- The number of units of a given item in the combined force structure which are required to be operationally available at D-Day to meet a given contingency.

- The number of units of a given item in the combined force structure which are required to be operationally available at P-Day to assure mission success for a given contingency.

- The combined estimated combat attrition rate and item failure rate during the D-P time period.

- The D-P time period for a given item.

- The organizational or field level repair cycle time.

- The depot level repair cycle time.

- The elapsed time after D-Day until the initial wartime procurements (i.e., procurements placed on or after D-Day) have been received and are operationally available for use.

- The average wartime supply rate until P-Day.

- The estimated number of units of a given item in the peacetime supply inventory on D-Day which are in a ready for issue condition including prepositioned war reserves.

- The per cent of failed or damaged items which can be repaired at organizational or field level.
- The per cent of failed or damaged items which can be repaired at depot level.

13. When funds are insufficient to satisfy all pre-positioned war reserve requirements, available funds will be allocated among the items requiring war reserves only after consideration has been given to: a) the relative essentiality of the items; b) the relative importance of the contingencies for which the items are held; c) the relative probabilities of contingency occurrence; and d) the relative importance of the component forces which are planned to be used to meet the contingencies.

14. When funds are insufficient to satisfy all general mobilization reserve requirements, available funds will be allocated among the items requiring war reserves only after consideration, on a sampling basis, for item essentiality, mission essentiality, and component force essentiality.

Long-Range Solution

It is recommended that OASD(I&L) initiate an in-depth study, with cooperation by the military services, to further develop, test, and evaluate the methods described in this report for establishing quantitative measurements of item essentiality,

contingency essentiality and component force essentiality. It is recommended that the three methods described for examining item essentiality, namely a) the systems network analysis, b) Min/Max equipment requirements analysis and c) the balanced equipment allowance analysis, be included in the in-depth study; and that each method be coupled with measurements of contingency and component force essentiality.

APPENDIX A

ASSISTANT SECRETARY OF DEFENSE
Washington, D. C.

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Installations and Logistics

DATE: 23 JUL 1971

TASK ORDER SD-271-160
(Task 72-4)

1. Pursuant to Articles I and III of the Department of Defense Contract No. SD-271 with the Logistics Management Institute, the Institute is requested to undertake the following task:

A. TITLE: Identification of War Reserve Stock

B. SCOPE OF WORK: The purpose of this task is to develop more definitive criteria to apply in identifying war reserve stock, and to develop recommended DoD policies which prescribe requirements for using such criteria. The criteria developed should be sufficiently definitive to: a) provide a basis for identifying war reserve items and stock uniformly among the military departments; and b) allow for an effective and balanced allocation of war reserve funds among the military departments and various commodities within the military departments.

In performing this task LMI will accomplish the following:

1. Identify current methods used by the military departments in determining items and range of war reserve stock.

2. Identify major problem areas resulting from the use of current policies and methods for identifying war reserve stock, and develop recommended short term and long range solutions.

3. Develop and analyze alternative methods and criteria for identifying war reserve items and stock and recommend the most appropriate criteria to apply.

2. SCHEDULE: A final report will be submitted by 31 March 1972.

Edward A. Gibson

ACCEPTED Wm. F. Eiman

DATE 28 July 1971

APPENDIX 2

APPENDIX 2

CLASSES ELIMINATED BY FLEET MATERIAL SUPPORT OFFICE DURING GENERAL MOBILIZATION RESERVE COMPUTATIONS

FSC	DESCRIPTION	IMM
3550	Vending and Coin Operated Machines	GSA
3610	Printing, Duplicating and Bookbinding Equipment	DGSC
3611	Industrial Marking Machines	DIPEC
3620	Rubber and Plastics Working Machinery	DIPEC
3635	Crystal and Glass Industries Machinery	DIPEC
3650	Chemical and Pharmaceutical Products Manufacturing Machinery	DIPEC
3655	Gas Generating and Dispensing Systems, Fixed or Mobile	DGSC
3660	Industrial Size Reduction Machinery	DIPEC
3680	Foundry Machinery, Related Equipment and Supplies	DIPEC
3685	Specialized Metal Container Manufacturing Machinery and Related Equipment	DIPEC
3693	Industrial Assembly Machines	DIPEC
3694	Clean Work Stations, Controlled Environment, and Related Equipment	DIPEC
3695	Miscellaneous Special Industry Machinery	DIPEC
3710	Soil Preparation Equipment	DCSC
3720	Harvesting Equipment	DCSC
3740	Pest, Disease, and Frost Control Equipment	DCSC
3750	Gardening Implements and Tools	GSA
3770	Saddlery, Harness, Whips, and Related Animal Furnishings	DCSC
4120	Self-Contained Air Conditioning Units and Accessories	DGSC
5410	Prefabricated and Portable Buildings	DCSC
5420	Bridges, Fixed and Floating	DCSC
5430	Storage Tanks	DCSC
5440	Scaffolding Equipment and Concrete Forms	DCSC
5450	Miscellaneous Prefabricated Structures	DCSC

FSC	DESCRIPTION	IMM
5610	Mineral Construction Materials, Bulk	GSA
6635	Physical Properties Testing Equipment	DGSC
6655	Geophysical and Astronomical Instruments	DGSC
6820	Dyes	DGSC
7105	Household Furniture	GSA
7110	Office Furniture	GSA
7125	Cabinets, Lockers, Bins and Shelving	GSA
7195	Miscellaneous Furniture and Fixtures	GSA
7210	Household Furnishings	DPSC
7220	Floor Coverings	GSA
7230	Draperies, Awnings, and Shades	GSA
7240	Household and Commercial Utility Containers	GSA
7290	Miscellaneous Household and Commercial Furnishings and Appliances	GSA
7420	Accounting and Calculating Machines	GSA
7430	Typewriters and Office Type Composing Machines	GSA
7460	Visible Record Equipment	GSA
7490	Miscellaneous Office Machines	GSA
7610	Books and Pamphlets	DGSC
7660	Sheet and Book Music	DGSC
7690	Miscellaneous Printed Matter	DGSC
7710	Musical Instruments	GSA
7720	Musical Instrument Parts and Accessories	GSA
7730	Phonographs, Radios, and Television Sets: Home Type	GSA
7740	Phonograph Records	GSA
7810	Athletic and Sporting Equipment	GSA
7820	Games, Toys, and Wheeled Goods	GSA
7830	Recreational and Gymnastic Equipment	GSA
7910	Floor Polishers and Vacuum Cleaners	GSA

FSC	DESCRIPTION	IMM
8310	Yarn and Thread	DPSC
8315	Notions and Apparel Findings (exclusive of procurement of coated cloth tape used in repair of lighter than air envelopes)	DPSC
8320	Padding and Stuffing Materials	DPSC
8325	Fur Materials	DPSC
8330	Leather	DPSC
8335	Shoe Findings and Soling Materials	DPSC
8410	Outerwear, Women's	DPSC
8425	Underwear and Nightwear, Women's	DPSC
8435	Footwear, Women's	DPSC
8445	Hosiery, Handwear, and Clothing Accessories Women's	DPSC
8450	Children's and Infants' Apparel and Accessories	DPSC
8460	Luggage	DPSC
8510	Perfumes, Toilet Preparations and Powders	GSA
8520	Toilet Soap, Shaving Preparations and Dentifrices	GSA
8530	Personal Toiletry Articles	GSA
8540	Toiletry Paper Products	GSA
8710	Forage and Feed	GSA
8720	Fertilizers	GSA
8730	Seeds and Nursery Stock	GSA
8975	Tobacco Products	DPSC
9110	Fuels, Solids	DGSC
9130	Liquid Propellants and Fuels, Petroleum Base	DGSC
9135	Liquid Propellant Fuels and Oxidizers, Chemical Base	DGSC
9140	Fuel Oils	DGSC
9340	Glass Fabricated Materials	DGSC
9350	Refractories and Fire Surfacing Materials	DGSC
9390	Miscellaneous Fabricated Nonmetallic Materials	DGSC

FSC	DESCRIPTION	IMM
9545	Plate, Sheet, Strip, Foil, and Wire: Precious Metal	DISC
9905	Signs, Advertising Displays, and Identification Plates	GSA
9910	Jewelry	GSA
9915	Collectors' Items	GSA
9920	Smokers' Articles and Matches	GSA
9925	Ecclesiastical Equipment, Furnishings, and Supplies	DGSC
9930	Memorials; Cemeterial and Mortuary Equipment and Supplies	DGSC
9999	Miscellaneous Items	DGSC

APPENDIX 3

APPENDIX 3

MATHEMATICAL METHOD FOR QUANTIFYING ESSENTIALITY JUDGMENTS

This Appendix describes the method for quantifying measurements of contingency and component force essentiality referred to in Section C.4 of the report. Since the method is the same for either contingencies or component forces, contingencies will be addressed to describe the method for both. The method is generally applicable to problems where a set of distinct entities (contingency essentiality judgments) are provided and it is necessary to assign to each individual entity a numerical weight that will represent the entity's relative "essentiality," "significance" or "importance." It is assumed that it is not possible to obtain these numerical weights through direct physical measurements; it is possible, however, to obtain comparative judgments on pairs of entities-based on cumulative experience in dealing with these or similar entities (on the operating, planning, or decision making level) and containing sufficient information to permit quantification.

To present the concept of the method, Section A of this Appendix will provide a detailed description of the basic method in terms of the "likelihood of occurrence" of "contingencies," in parallel with pages 67 - 69 of Chapter II, Section C.4 of the report. Section B of this Appendix will then describe how the basic method is applied to "relative importance" of "contingencies;" and how "likelihood of occurrence" and "relative importance" weights are combined into a single weight representing the relative essentialities of contingencies.

A. Relative Likelihood of Occurrence

Section A of this Appendix is presented in six sub-sections as follows:

1. Introduction
2. The Matrix of Quantified Judgments
3. Dependence on Mathematical Formulation
4. Steps toward Mathematical Formulation
5. Mathematical Formulation
6. Computational Procedure

Sub-section 4. contains three steps, numbered 1 through 3; sub-section 6 contains 5 steps, numbered 1 through 5. Principal mathematical statements or equations are identified at the left hand margin by parenthetical numbers beginning with (0).

1. Introduction

Assume n contingencies are being considered by a group of appropriate military experts. The group's objective is:

a) to provide judgments on relative likelihood of contingencies;

b) to insure that the judgments in a) contain (explicitly or implicitly) quantitative elements to an extent that permits quantitative interpretation of each judgment in the set that connects all contingencies.

Part b) of the group's objective will require appropriate technical assistance. The objective in this Appendix is:

c) to describe a method for deriving, from the group's quantified judgments (i.e., from the relative values associated with pairs of contingencies) a set of weights to be associated with individual contingencies; these weights should reflect the group's quantified judgments (in a sense to be defined in sub-section 4) and facilitate their use.

The choice of designation "weights" should emphasize that these numbers bear meaning only in the relative sense, i.e., through their ratios. Bearing this in mind, the set of weights is precisely as good, or as bad, an estimate of the situation as the judgments in a) and b), together (i.e., the judgments provided by the group in a) and any additional judgments by the group and its technical assistants entering, directly or indirectly, in the process of insuring and achieving quantitative interpretation). The method in c) is purely mathematical; it neither adds nor deletes any information. But what it achieves is putting the information resulting from a) and b) into usable form.

2. The Matrix of Quantified Judgments

Let $C_1, C_2, \ldots, C_n$ be the set of contingencies. The quantified judgments on pairs of contingencies C_i, C_j are represented by an n-by-n matrix

$$B = (b_{ij}), \quad (i,j=1,2, \ldots n),$$

whose entries b_{ij} are defined by the following entry rules:

Rule 1. If C_i is judged to be k times as likely as C_j, then $b_{ij} = k$, $b_{ji} = \frac{1}{k}$

Rule 2. If C_i is judged to be just as likely as C_j, then $b_{ij} = 1$, $b_{ji} = 1$; in particular $b_{ii} = 1$ for all i

Rule 3. If C_i is beyond quantifiable comparison with C_j, then $b_{ij} = 0 = b_{ji}$ (to indicate "no quantifiable judgment available")

Thus, if say $b_{35} = 2$, this signifies that the quantified judgment on pairs C_3, C_5 has been that C_3 is 2 times as likely as C_5.

3. Dependence on Mathematical Formulation

Having recorded the quantified judgments on pairs (C_1, C_j) as numerical entries b_{ij} in the matrix B, the problem now is to assign to the n contingencies $C_1, C_2, \ldots C_n$ a set of numerical weights $W_1, W_2, \ldots, W_n$ that would "reflect the recorded judgments."

In order to do so, the vaguely formulated problem must first be transformed into a precise methematical one. This obviously necessary, and apparently harmless step is the most crucial one in any problem that requires the representation of a real-life situation in terms of abstract mathematical structure. It is particularly crucial in the present problem where the representation involves a number of transitions that are not

immediately discernible. It appears, therefore, desirable in the present problem to identify the major steps in the process of representation and to make each step as explicit as possible, in order to enable the potential user to form his own judgment on the meaning and value of the method in relation to his problem and his objective.

4. Steps Toward Mathematical Formulation

It is convenient to first get a simple question out of the way. The matrix B of quantified judgments b_{ij} (as defined in sub-section 2) may have many, or only few, non-zero entries. The question arises: how many non-zero entries (i.e., how many quantifiable judgments) are necessary in order to insure the existence of a set of weights that is meaningful in the context of the problem? The obvious answer is: it is necessary that there be a set of non-zero entries that interconnects all contingencies in the sense that for every two indices, i,j, there should be some chain of non-zero entries connecting i with j:

(0) $$b_{ii_1},\ b_{i_1i_2},\ b_{i_2i_3},\ \ldots,\ b_{i_kj}.$$

(when $b_{ij}\neq 0$, b_{ij} itself is such a chain - of length 1). This gives precise content to the formulation in b) of sub-section 1.

The major question is the one concerned with the meaning of the vaguely formulated condition in c) of sub-section 1: ... "these weights should reflect the group's quantified judgments."

This presents the problem of describing, in precise, arithmetic terms, how the weights W_i should relate to the judgments b_{ij}, or, in other words, the problem of specifying the conditions we wish to impose in the weights we are seeking in relation to the judgments obtained. The desired description shall now be developed in 3 steps, proceeding from the simplest special case to the general one.

Step 1. Assume first that the "judgments" are merely the result of precise physical measurements. Say the judges are given a set of pebbles, $C_1, C_2, \ldots, C_n$ and a precision scale. To compare C_1 with C_2, they put C_1 on the scale and read off its weight, say $W_1 = 305$ grams. They weigh C_2 and find $W_2 = 244$ grams. They divide W_1 by W_2, which is 1.25. They pronounce their judgment, "C_1 is 1.25 times as heavy as C_2" and record it as $b_{12} = 1.25$. Thus, in this ideal case of exact measurements the relations between the weights W_i and the judgments b_{ij} are simply stated by:

$$(1) \qquad \frac{W_i}{W_j} = b_{ij} \qquad (\text{for } i,j = 1,2,\ldots,n)$$

However, it would be unrealistic to require these relations to hold in the general case. Imposing these stringent relations would, in most practical cases, make the problem of finding the W_i (when b_{ij} are given) insolvable. First, because even physical measurements are never exact in a mathematical sense, and hence, allowance must be made for statistical deviations; second, because in human judgments these deviations are considerably larger.

Step 2. In order to see how to make allowance for statistical deviations, consider the i^{th} row in the matrix B. The entries in that row are:

$$b_{i1},\ b_{i2},\ \ldots b_{ij},\ldots,\ b_{in}$$

In the ideal (exact) case these values are the same as the ratios

$$\frac{W_i}{W_1},\quad \frac{W_i}{W_2},\quad \ldots\ \frac{W_i}{W_j}\quad \ldots\ \frac{W_i}{W_n}$$

Hence, in the ideal case, if we multiply the first entry in that row by W_1, the second entry by W_2, and so on, we would obtain

$$\frac{W_i}{W_1}\,W_1 = W_i,\ \frac{W_i}{W_2}\,W_2 = W_i\ ,\ \ldots.\frac{W_i}{W_j}\,W_j = W_i,\ \ldots,$$

$$\frac{W_i}{W_n}\,W_n = W_i$$

That is, a row of identical entries

$$W_i,\ W_i,\ldots,W_i,$$

Whereas in the general case we would obtain a row of entries that represent a statistical scattering of values around W_i. It appears therefore reasonable to require that W_i should equal the mean of these values. Consequently, instead of the ideal case relations (1), which can also be written in the form

(1') $$W_i = b_{ij}W_j \qquad (i,j=1,2,\ldots n)\ ,$$

the more realistic relations for the general case take the form: for each fixed i,

$$W_i = \text{the mean of } b_{i_1}W_1,\ bi_2W_2,\ \ldots,b_{in}W_n$$

More explicitly, and allowing for the possibility of some $b_{ij}=0$ due to absence of quantifiable judgment, this relation reads:

$$(2) \qquad W_i = \frac{1}{r_i} \sum_{j=1}^{n} b_{ij} W_j \qquad (i=1,2,\ldots,n)$$

Where r_i = the number of non-zero entries in the i^{th} row of B, i.e., the number of non-zero terms in the summation.

While it is clear that the relations in (2) represent a substantial relaxation of the more stringent relations in (1), there still remains the question: is the relaxation <u>sufficient</u> to assure the existence of solutions; that is, to assure that the problem of finding the weights W_i when the b_{ij} are given is a solvable one.

<u>Step 3.</u> To seek the answer to the above essentially mathematical question, it is necessary to express the relations (2) in still another, more familiar form. For this purpose divide each entry in the i^{th} row of B by r_i (r_i=the number of non-zeros entries in the i^{th} row). Having done this for each i, call the new matrix so obtained: $A = (a_{ij})$. Thus, A is the matrix defined by

$$(3) \qquad A_{ij} = \frac{1}{r_i} b_{ij}. \qquad (i,j=1,2,\ldots,n)$$

Further, denote by W the column vector (the weight vector)

$$W = (W_1, W_2, \ldots, W_n)'.$$

Then the relations in (2) take the form

$$(4) \qquad AW = W$$

This means: given the matrix A, the weight vector W should be such that it is a fixed point under A (if A is viewed as linear transformation on euclidean n-space); and our question now reads: given the matrix A, does there always exist a weight vector W (that is, a vector with positive coordinates) satisfying relation (4); or, in other words: does equation (4) always have a solution W with positive coordinates?

The formulation (4) shows that our question belongs to the spectral theory of linear transformations, where the answer is provided by a theorem of Frobenius. (For reference see Note at the end of this Appendix). The theorem states:

> If A is an irreducible matrix with non-negative entries, then the equation
>
> $$AW = \lambda W$$
>
> subject to $\lambda > 0$, $W > 0$
>
> always has a unique solution, in the sense that the eigenvalue λ is unique and the eigenvector W is unique up to scalar multiples.

Here, "irreducible" is just a short term for the requirement that the non-zero entries in A (and hence also in B) should interconnect all indices, as has been formulated as condition (0); $W > 0$ means that all coordinates of W should be positive.

Comparison of the theorem with our condition (4), which can also be written as $AW = 1W$, immediately shows that the answer to

our question is negative: from the theorem that $AW = \lambda W$ always has a unique solution (with $\lambda > 0$, $W > 0$) it follows that $AW = 1W$ cannot always have a solution (with $W > 0$); namely; whenever the unique solution to $AW = \lambda W$ has $\lambda \neq 1$, there is no solution to $AW = 1W$.

Let us summarize the line of reasoning to this point. In seeking a set of conditions to describe how the weight vector W should relate to the quantified judgments, we first considered the ideal (exact) case in step 1, which suggested the relations (1). Next, realizing that the real case will require allowances for statistical deviations, we provided for such allowances in step 2, leading to the formulation (2) and the equivalent formulation (4). Now, the Frobenius theorem tells us that our allowances are still not realistic enough, that is, that (4) is still too stringent to assure existence of a weight vector W that would satisfy it.

5. Mathematical Formulation

The Frobenius theorem does give us more than just that negative answer. It tells us precisely what must be done to make the relations realistic enough so as to assure not only the existence of a solution but also its uniqueness, and hence, to achieve precisely what we are after. It tells us to replace the too stringent relation by the weaker relation $AW = W$ $(W > 0)$.

$$(5) \qquad AW = \lambda W \qquad (\lambda > 0, \quad W > 0)$$

which represents the final formulation of the problem.

It is worthwhile to discuss the meaning of this additional relaxation implicit in (5). For this purpose, recall the first two steps. The ideal case considered in step 1 led to the condition that, for each fixed i, the set of values

$$b_{i1}W_1,\ b_{i2}W_2,\ \ldots,\ b_{in}W_n$$

should all be equal to W_i (whenever they are not zero). In the general real case considered in step 2, allowance for statistical deviations led to the weaker condition that the mean of those values should equal W_i. Now relation (5) suggested by the theorem amounts to the requirement that the mean of those values should equal, not W_i, but rather some positive multiple of W_i, whereby the multiplier λ would be the same for all i. This means that the additional relaxation amounts to admitting a uniform change of scale in the quantified judgments. To see this, note that (5) can also be written in the form

$$\left(\frac{1}{\lambda}A\right) W = W \qquad (\lambda > 0,\ W > 0),$$

which, compared with (4), merely replaces the matrix A by $\frac{1}{\lambda}A$. This multiplication by $\frac{1}{\lambda}$ is precisely a change of scale for the entries in A and, hence, for the entries in B; it includes the special case of no change, when $\lambda = 1$; the scale is contracted when $\lambda > 1$, and expanded when $\lambda < 1$.

A conclusion of practical importance is the following. If, after having obtained the solution λ and W, the columns of the matrix B are multiplied by the coordinates of W (the first column by W_1, the second by W_2, etc.) a look at this new matrix--

call it B*-and at the value of λ will tell how close the judgments have been to the ideal case, (i.e., how much precision they contain). The closer the entries in each row are to the mean of that row (i.e., the smaller the variance) and the closer λ is to 1, the closer the judgments will have been to the ideal case and, hence, the larger their precision.

6. Computational Procedure

The procedure for finding the solution to (5) is purely mathematical and is briefly described in the following steps.

Step 1. It must be made sure that in the matrix B of quantified judgments that the set of non-zero entries connects all indices in the sense of condition (0) in sub-section 4.

Step 2. Every row in B (that is, every entry in that row) is then divided by the number of non-zero elements in that row, thus, resulting in a matrix

$$A = (A_{ij}), \quad A_{ij} = \frac{b_{ij}}{r_i}$$

where r_i = the number of non-zero elements in the i^{th} row of B.

Step 3. Beginning with the column vector $W_o = (1,1,\ldots,1)'$ (a column of n ones) the transformation A is applied to W_o, yielding a vector V_1, which is then normalized to sum=1, to yield a vector W_1, that is $AW_o = V_1$, $W_1 = \frac{V_1}{\text{sum of elements in } V_1}$

Step 4. Step 3 is repeated with W_1 (that is $AW_1 = V_2$, V_2 is normalized to W_2) then with W_2, W_3, ...

Step 5. The iteration is terminated when, for some integer m,

$$W_m = W_{m-1}.$$

W_m, now simply denoted by W, is the desired weights vector (i.e., the set of weights, and λ = sum of the coordinates of V_m.

B. Relative Importance

If the judgments are performed in one step through pair-wise comparisons, the method is the same as in Section A provided the word "likely" is replaced by the word "important."

If the judgments on relative importance are made with respect to a number of independent properties, say the properties

(1) $$P_1, P_2, \ldots P_N,$$

(designating political, economic, military, etc. threat), the procedure, for <u>each</u> of the properties, is still the same as in Section A. Just replace "likely" by "important with respect to property P_k," and denote the resulting weight vector by q^k instead of W. Thus, application of the procedure for each of the N properties will yield N weight vectors

(2) $$q^1, q^2, \ldots q^N$$

Each of these vectors has n coordinates, representing weights assigned to the n contingencies with respect to the specific property. Hence, each contingency now has N weights assigned

to it, one weight for each of the properties considered. In order to obtain, for each contingency, a single weight representing the relative overall importance of that contingency, the n weights must be combined into a single one. This means that the N weight vectors in (2) must be combined into a single weight vector.

To combine the N weight vectors of (2) into a single relative importance weight vector, judgments must be obtained on the relative importance of the properties in (1) - without regard to individual contingencies. The procedure here is again the same as described in Section A if: "likely" is replaced by "important;" n is replaced by N; C is replaced by q; W is replaced by t. This will lead to a (normalized) weight vector

$$t = (t_1, t_2, \ldots, t_N)'$$

whose coordinates represent the relative importance of the N properties.

Assuming that all N vectors in (2) have been normalized, the desired single relative importance weight vector u for the contingencies is then obtained by

$$u = t_1 q^1 + t_2 q^2 + \ldots + t_N q^N \tag{3}$$

Considering now the two weight vectors assigned to the contingencies - namely W, whose coordinates represent relative likelihood of occurrence, and u, whose coordinates represent relative importance - they must be combined into a single weight

vector. This is done by taking the product of the two weights for each contingency and normalizing the resulting vector. In other words:

if $W = (\alpha_1, \alpha_2, \ldots, \alpha_n)'$ and $u = {}_1\beta_2, \ldots, B_n)'$,
then the vector

$$r = (\alpha_1\beta_1, \alpha_2\beta_2, \ldots, \alpha_n\beta_n)' = (r_1, r_2, \ldots, r_n)'$$

is normalized (to sum=n, say) to yield the normalized vector

$$s = \frac{n}{\text{sum of all } r_i} \cdot r = (s_1, s_2, \ldots, s_n)$$

where $$s_i = \frac{nr_i}{\text{sum of all } r_i} .$$

NOTE: The procedure in sub-sections 2-6 derives from a theorem of Perron and Frobenius (see Gantmacher, the Theory of Matrices, Vol. II, p. 53 and 63) and has been used for various purposes (see C. Berge, The Theory of Graphs, Wiley 1962, pp. 135-138; D. Gale and L. S. Shapley, College Admissions and the Stability of Marriage, Am. Math. Monthly, Vol. 69, Jan. 1962, pp. 9-14). Its extension fc use to assign weights to properties is due to T. L. Saaty. The version of the procedure presented here is a modification for increased ins ght.

APPENDIX 4

APPENDIX 4

PROPOSED MATHEMATICAL FORMULA FOR UNIFORM COMPUTATION OF WAR RESERVE REQUIREMENTS

Prepositioned War Reserves

The number of units of a given item required for prepositioned war reserve stockage should be based on maintaining a balanced force from the time the conflict begins (D-Day) until wartime resupply can be accomplished (P-Day). The contingency plan may call for an increase in the force structure after the conflict begins so that we are concerned with providing a sufficient quantity of war reserves to meet the required increase and also to replace the number of units lost from the initial D-Day force. At some point, P-Day, the force structure will have increased to its required size and wartime resupply will have been established to maintain the P-Day force structure in balance. During the period of D-P Day a certain quantity of war reserve materiel will be required. It is this quantity that we will compute.

For any given item, let:

N_{pj} = The number of prepositioned war reserve units required for the combined force structure to successfully meet the j^{th} contingency;

n_2 = the number of operational units required on P-Day for the combined force structure to successfully meet the j^{th} contingency; and

n_R = the number of operational units available on P-Day from an initial D-Day force;

so that

Eq. (1) $N_{pj} = n_2 - n_R$

The number of operational units required on P-Day (n_2) will be stipulated as part of the contingency plan. The number of operational units available on P-Day from an initial D-Day force (n_R) must be computed and will depend on three types of deletions or additions to the initial D-Day force. These are: 1) the number of units lost due to battle attrition, failure and wear out; 2) the number of lost units which can be returned to the D-Day force by repair at organizational or field levels; and 3) the number of new units which can be added to the D-Day force through wartime resupply or wartime procurement.

1. Loss caused by battle attrition, failure and wear out

Let n_1 = the number of operational units of a given item available on D-Day in the combined force structure;

r_1 = the estimated combined battle attrition rate, failure rate and wear out rate during the D-P time period expressed as a per cent of the initial D-Day force (n_1) per month; and

t_1 = the D-P time period for a given item in months.

Thus, the loss to the initial D-Day force can be expressed as follows:

$$\text{D-Day force loss} = n_1 - n_1(1-r_1)^{t_1}$$

2. Replenishment via Repair

Let k_f = the per cent of the units lost during the D-P time period, caused by attrition failure and wear out, that can be repaired at organizational or field level and returned to the D-Day force structure, and

t_f = the organizational or field level repair cycle time.

Thus,

$$\text{Replenishment via Repair} = k_f n_1 \left(1-(1-r_1)^{t_1-t_f}\right)$$

3. Replenishment via New Procurement or Resupply

When D-Day for a given contingency occurs, new procurements or resupply actions are normally initiated to achieve wartime resupply. At some point, P-Day, the resupply rate will equal the wartime consumption rate. In the meantime, it is often possible to provide some resupply to the combat operation, even though the resupply rate is not sufficient to offset the wartime consumption until P-Day. The quantity of units added to the D-Day force through resupply until P-Day must be considered. In most cases, some period of time will elapse between D-Day and the time resupply to the using force structure begins. Let us identify this period of time as t_e. Now, the number of units which can be added to the D-Day force through resupply until P-Day can be expressed as follows:

$$\text{Replenishment via Resupply} = r_2(t_1-t_e), \text{ where}$$

r_2 = the average wartime supply rate for a given item from t_e through t_1.

The number of operational units available on P-Day' (n_R) from an initial D-Day force (n_1) is the sum of the initial D-Day force, the replenishment via repair and the replenishment via resupply less the D-Day force losses caused by attrition, failure and wear out.

Thus,

$$n_R = n_1(1-r_1)^{t_1} + k_f n_1 \left(1-(1-r_1)^{t_1-t_f}\right) + r_2(t_1-t_e)$$

Substituting the above expression for n_R into equation (1), the prepositioned war reserve requirements, for a given item required by a specific component force to meet the j^{th} contingency, may be computed as follows:

$$N_{pj} = n_2 - \left[n_1(1-r_1)^{t_1} + k_f n_1 \left(1-(1-r_1)^{t_1-t_f}\right) + r_2(t_1-t_e) \right]$$

● General Mobilization Reserves

The mathematical equation for computing general mobilization reserves can be formulated in the same way as the equation for prepositioned war reserves. However, in the case of general mobilization reserves, additional units of a given item can be made available to the initial D-Day force in two ways:

1) replenishment via depot level repair; and 2) use of the peacetime stock and the prepositioned war reserve stock.

Thus, the formula for computing the number of units of a given item required for general mobilization reserves to meet a major contingency (J), is as follows:

$$N_{GJ} = n_2 - \left[n_1(1-r_1)^{t_1} + k_f n_1 \left(1-(1-r_1)^{t_1-t_f} \right) + k_d n_1 \left(1-(1-r_1)^{t_1-t_d} \right) + r_2(t_1-t_e) + n_s \right]$$

where,

N_{GJ} = the number of units of a given item required as general mobilization reserves for the combined force structure required to meet a major contingency (J).

n_1 = the number of units of a given item in the combined force structure required to meet a given contingency which are operationally available at D-Day.

n_2 = the number of units of a given item in the combined force structure required to meet a given contingency which are required to be operationally available at P-Day to assure mission success.

r_1 = the combined estimated combat attrition rate and item failure rate during the D-P time period expressed as per cent of the D-Day force structure (n_1) per month.

t_1 = the D-P time period for a given item in months.

t_f = the organizational or field level repair cycle time in months.

t_d = the depot level repair cycle time in months.

t_e = the elapsed time in months after D-Day until the initial wartime procurements (i.e., procurements placed on or after D-Day) have been received and are operational available for use.

r_2 = the average wartime supply rate in months from t_e to t_1.

n_s = the estimated number of units of a given item in the peacetime supply inventory on D-Day which are in a ready for issue condition and the number of units of prepositioned war reserves.

k_f = the per cent of failed or damaged items which can be repaired at organizational or field level.

k_d = the per cent of failed or damaged items which can be repaired at depot level.

The data required to apply the proposed formulae for computing prepositioned war reserve requirements and general mobilization reserve requirements are presently available within the military services, although at the present time the National Inventory Control Points (NICPs) may not have ready access to the data in the precise form indicated by the formulae. In developing data inputs each NICP should strive to quantify the data elements as realistically as possible under wartime conditions. Certain data inputs should be refined and determined only after trade-off analyses have been made. For instance, the D-P time (t_1), the elapsed time from D-day until receipt of wartime procurements (t_e), and the average wartime supply rate (r_2) should all be subjected to trade-off analysis. In compiling these data (t_1, t_e, and r_2) from current production sources, trade-offs should be made between the different time and rate factors and the acquisition costs of the war reserve materiel. A method for examining trade-offs among different D-P times is proposed in Chapter II, Section B.8 of this report.